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ON THE CELLS OF THE SPINAL GANGLIA AND ON THE RELATIONSHIP OF THEIR HISTOLOGICAL STRUCTURE TO THE AXONAL DISTRIBUTION.

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INTRODUCTION.

THE importance of the spinal ganglia in physiology and in pathology has long made the structure of these bodies

an object of research for neurologists. The striking and familiar features are the marked variation in size of the component cells, and the very different appearances these cells show when stained in an appropriate manner. Attempts have been made to correlate these differences with the fact that the cells are the nutritional centres for nerve fibres distributed to very different tissues of the body. Our communication is a further endeavour in this direction.

Since the discovery of Ranvier that the cells of the ganglia gave origin to an axon dividing immediately into a peripheral and central process, some new facts of importance have been ascertained.

Firstly.—The elaborate studies with the Nissl method made by many observers, which have culminated in the admirable work of Lugaro (1) have shown that a classification of the cells may be made on account of the different appearances they present when stained by this method, and that the types thus recognised may be found in all animals.

Secondly.—Numerical observations, chiefly from the Chicago laboratory of Professor Donaldson, have brought out interesting and suggesting facts, notably the excess in number of cells over fibres in the posterior roots.

Thirdly.—It has been shown that besides the usual cell with the T-shaped axon of Ranvier there are in the ganglia other kinds of cells. Dogiel (2) [1] from preparations made by Ehrlich's methylene blue method, has described multipolar cells. He states that they are scanty in number, and that their processes may or may not have a myelin sheath. He was unable to follow their processes beyond the ganglion. The existence of these cells has been confirmed by several observers. Dogiel has also described cells whose axones are short and divide very often, ending in a pericapsular and pericellular basket situated around the ordinary type of cells. They therefore resemble the Golgi cell of type II. met with n other parts of the nervous system, and may be looked upon as relay cells. They belong to the smaller class of cells and are not numerous.

[1] In Bayliss' Paper (*loc. cit.*) there is a diagram which shows plainly the types of cells described by Dogiel.

The ganglion is therefore a more complicated structure than was formerly thought; it is a nucleus of termination as well as of distribution. In this paper we give the result of observations chiefly based on a more detailed method of using the "axonal reaction" than has previously been attempted, and endeavour to show that they suggest an answer to some of the problems indicated by the foregoing sketch.

Methods Used.

Our experimental lesions have all been made on cats, and no results accepted unless healing without visible reaction occurred. In each case the animal was allowed to live fourteen days, except in the last experiment.

The method of intra-vitam fixation was used in all cases. The vascular system was first thoroughly washed out with normal saline, and afterwards Mann's fixing fluid of corrosive sublimate, picric acid and formalin allowed to run through the vessels. The fluids were used at a temperature of 38° C. After complete saturation of the tissues with this fluid, the ganglion was removed as speedily as possible and placed in the same fluid for an hour. We found the best results were obtained by a rapid method of embedding, the ganglion being passed through the several dehydrating and clearing agents at a temperature of about 38° C., and remaining in each of these and the final paraffin bath for from 10 to 15 minutes. In this way we obtained many preparations in which the fixation seemed to be perfect. Of dyes, we found toluidin blue used alone to be the best, and, if neutral balsam is used, the stain is permanent for at least many months.

As a rule a counter-stain with erythrosin was not used, since this dye, unless very faint, prevents the finest granules staining with the blue, a fact alluded to by Lugaro and by Orr and Rows (3).

The position of the ganglion examined was ascertained after counting the ribs, which in all instances numbered thirteen.

Serial sections of $\frac{1}{150}$ mm. thickness were cut usually through the whole extent of the ganglion, and consecutive series of ten examined in order that the whole of any one cell might if necessary be observed.

With regard to the chromatolysis produced by the various lesions, we are satisfied that in the normal animal there are no cells which cannot after careful examination be distinguished from cells in a state of chromatolysis. If a cell is cut through the axon hillock it can readily be distinguished by the normal characteristics of the remaining Nissl granules. Other deceptive appearances are cleared up by adopting the rule never to consider cells in which the nucleolus is not clearly visible. It is only amongst the small dark cells that reasonable doubt arises, but after careful staining by toluidin alone, and attention to the characteristic features described by Lugaro, especially the condition of the nucleus and its surrounding stained protoplasm, we are convinced that the margin of error is small.

Certain control experiments were made when necessary, and will be mentioned later.[1] The measurements of the sizes of cells and nerve fibres mentioned in the following pages were obtained as follows:—A Leitz drawing ocular was used, and having obtained by means of the usual micrometers the exact magnification produced by a given lens, with the draw tube of the microscope at 160 mm., the size of the image thrown on to a drawing paper was accurately measured by means of a steel rule graduated to $\frac{1}{10}$th of a millimetre.

By dividing this number by the ascertained magnification the size of the cell was obtained.

This method enabled us to readily measure a large number of cells, and is strictly accurate. The measurements given all relate to cells in which the nucleolus was

[1] At the Oxford Meeting of the British Medical Association, we had the pleasure of demonstrating our specimens to Dr. Orr, whose studies on the ganglion cells are so well known, and he kindly allows us to say that he agrees with the statement that in the normal animal it is very exceptional to meet with cells which can be confused with a true chromatolytic change, and also that in his opinion the appearances shown in our specimens could only have been the result of an experimental lesion.

clearly visible, and included the whole protoplasm as far as the innermost part of the capsule.

The Sizes of the Cells in Ganglia of Different Regions.

For this purpose we selected the second cervical, the eleventh dorsal, and the seventh lumbar ganglia, and 1,000 cells from each ganglion were measured in the manner described.

The second cervical receives fibres from the skin and small muscles, the eleventh dorsal in addition receives afferent visceral fibres, whilst the seventh lumbar has no visceral connections, but receives the sensory fibres from the large hamstring muscles.

The results obtained may be best represented graphically (fig. 1). The diameters of the cells were measured to the nearest even μ, and the curves given were obtained in the usual way from the actual measurements, which are not represented in the diagram. The divergence of the observed from the calculated numbers was not great, and left no doubt as to the interpretation.

In general terms the curves from the cervical and dorsal ganglia show great similarity in the proportion of cells of different sizes, which is strikingly confirmed by the facts that the greatest number in each case measure about 40 μ and that this figure also represents the mean diameter (actual figure = 41 μ). The curve of the lumbar ganglion is widely different, and is a double one, the second part representing added cells of larger size than exist in either the cervical or dorsal regions. The mean diameter of all the cells in this case being brought up to 55 μ. These added cells, as will be seen from the experimental results mentioned later, represent the large clear type, and are the cells in connection with the sensory organs, the muscle spindles of the large hamstring muscles.

They thus represent the added elements of the first sensory neuron consequent on the development of the limbs.

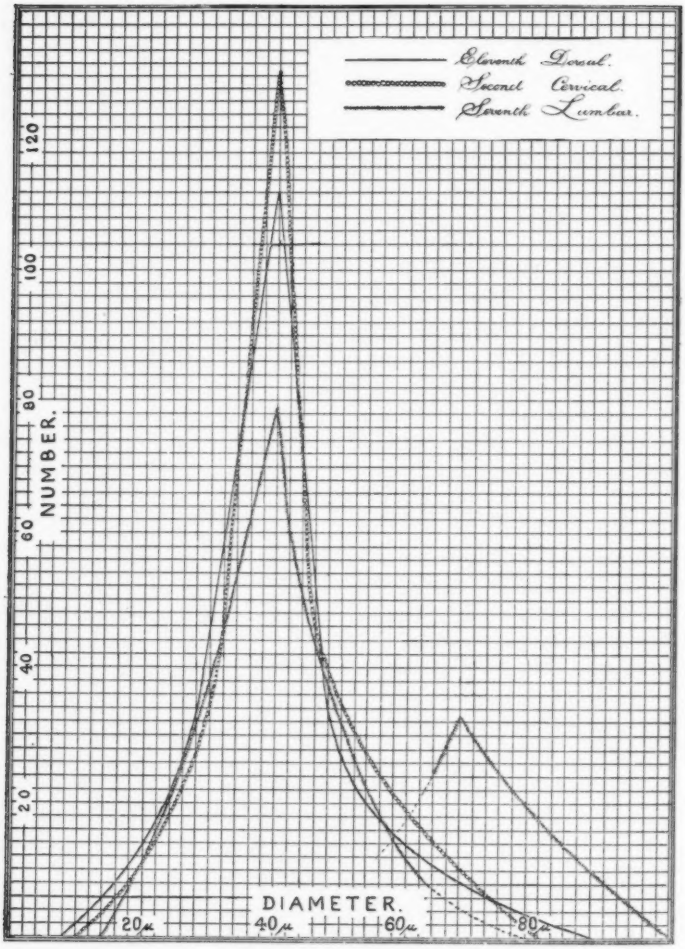


FIG. 1.

Curves showing the sizes of 1,000 cells in each instance from the second cervical, eleventh dorsal, and seventh lumbar ganglia. The similarity of the numbers of cells of different sizes in the second cervical and eleventh dorsal is shown. In the seventh lumbar the facts brought out are, (1) the smaller number of cells of medium diameter, (2) the added cells of large diameter (consequent on the connection of this region with large muscles of a limb).

The Types of Cells in the Ganglia, and a Review of Some of Lugaro's Conclusions.

It has been mentioned that Dogiel and others have described multipolar cells and cells of the Golgi type II. as present in the spinal ganglia. The Nissl method, whilst incapable of demonstrating these cells, has formed the basis of other methods of classification. The more important papers are those of Lenhossék (4), in 1895-96; Held (5); Marinesco (6), 1897; R. A. Flemming (7), 1897; Cox (8); van Gehuchten and Nelis (9), 1896. In addition to these papers Lugaro has published a long series of researches dating from 1896 to the present time, and some of his conclusions will be shortly noticed. The classification established by Lugaro's observations in animals has been extended to man by Orr and Rows (10), who also in their paper give a review of the work of previous observers.

Lugaro's observations were made on several kinds of animals, the rabbit, dog, cat and guinea-pig. In all these he recognised the same five types of cells.

(1) Large clear cells with granuliform chromophile elements scattered almost equally throughout the protoplasm, with a slight increase towards the cell periphery. The nucleus is large and clear, and there is a definite perinuclear and peripheral clear zone.

(2) Large and medium sized cells, with very fine chromophile elements, which are larger, however, at the periphery of the cell. Other characteristics as in type I.

(3) Small dark cells, with very fine chromophile elements, larger around the nucleus with which they are in contact. The fundamental substance and nucleus are diffusely coloured.

(4) Small and medium sized clear cells, with chromophile elements somewhat large but few in number. The nucleus is clear and separated from the chromophile substance by an achromatic zone.

(5) Large clear cells, with elongated chromophile elements lying concentrically around the nucleus in parallel

planes. The nucleus is always excentric, whereas in the other types it is almost uniformly central.

Orr and Rows (*loc. cit.*), John Turner (10) and ourselves, working after the publication of the major part of Lugaro's work, confirm in the main this classification, and hence the important position is reached that the same types of cells may be recognised in different mammalia.

Without entering into minute histological details, it is necessary that we should make a few observations regarding this classification, which we think may be simplified. Lugaro's types I. and II. are recognised by all, but we consider the sub-division an unnecessary refinement not always obvious. We find the size of the cells with this structure varies, within wide limits, from 35 μ to 100 μ. The peripheral clear zone has been recognised since E. Müller's paper (11). It is not a distinct membrane, but is merely cell protoplasm, from which chromophile granules are absent. In perfectly fixed specimens it is not readily visible, but becomes obvious when there is any cell retraction. Lenhossék even expressed the opinion that it might be an artefact. Increase, however, in this zone is not necessarily due to imperfect fixation, for we can confirm R. A. Flemming's observation that after section of the axon the zone is relatively increased. Cassirer (12) also notes this. The perinuclear clear zone exists in many of the larger cells, but not in all. Lenhossék says it is seen mostly in the largest cells. We subsequently allude to these types as the *Clear Cells*. Lugaro's type III. may be called *Obscure Cells*; they have been described and figured in all the papers we have consulted from Walther Flemming (13) onward. They are the most numerous cells in the ganglia and vary greatly in size, from 10 μ to 56 μ in our analyses, and hence include some of the smallest of the cells. Lugaro's type IV. we propose to call *Coarsely Granular Cells*; they are readily recognised under the low power of the microscope, and are very scantily represented, they have a fairly uniform size between 35 μ and 50 μ. Lugaro's type V. has been called by that writer the Vorticose Cell. It is stated by Lugaro and Orr and Rows to be very rare. We have been unable to clearly

recognise it, and hence must disregard it in a scheme of classification, a position also adopted by Turner. Lastly, amongst the smallest cells, in addition to the obscure cells, we find some in which the network is less dense, consisting of either fine or scanty largish granules. The fundamental protoplasm is not diffusely coloured, and the nucleus is always proportionately very large and usually central. These cells never exceed 25 μ in diameter, and a capsule cannot always be seen. We allude to them as the *Smallest Clear Cells.* (Fig. 2.)

Classified in this way our analyses give the following percentages :—

	2nd Cervical.	11th Dorsal.	7th Lumbar.
Clear cells	25·5	21·9	35·5
Obscure cells	68·1	72·6	56·8
Coarsely granular cells ...	4·3	2·5	3·7
Smallest clear cells... ...	1·9	2·6	4·2

Lugaro in his extensive research has shown that in the different types of cells the alteration following an axonal lesion and the subsequent fate of the cell vary, both in the rate and kind of change. Hence a cell may be recognised as belonging to a given type throughout the series of changes constituting reaction and repair. He claims that the different morphological types of cells in the sensory ganglia may be considered as specifically distinct, both from an anatomical and physiological standpoint.

The Ganglion Cells of the Human Fœtus.

Dr. A. S. Griffith and one of us have examined the spinal ganglia in the human subject at the third, fourth, sixth and eighth month of intra-uterine life. At full term the several types of cells present in the adult could be recognised, but at an earlier age this differentiation was absent, and the cells resembled considerably the smallest clear cells described above. It was found that the chromophile elements first appeared at the periphery of the cell. At the fourth month the cells were found to be of about the same size, and often showed double nucleoli; they were commonly grouped

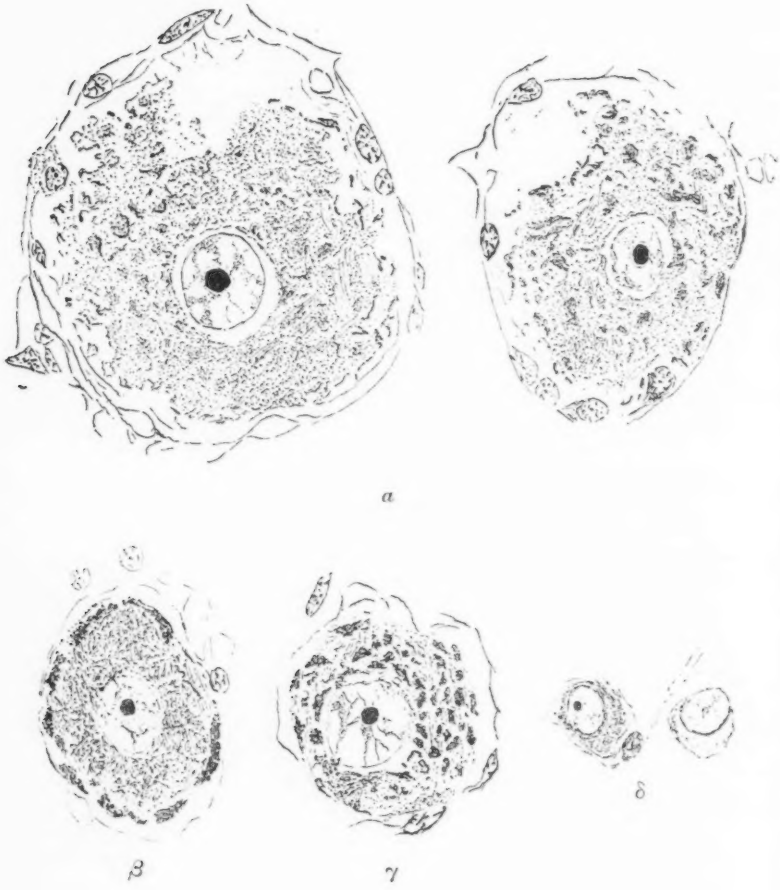


FIG. 2

Normal cells drawn from the seventh lumbar ganglion. Leitz $\frac{1}{12}$. Drawing ocular.

(α) Clear cells (86 μ and 70·3 μ).
(β) Obscure cell (53 μ).
(γ) Coarsely granular (43·8 μ).
(δ) Smallest cells, obscure and clear (17·2 μ and 15·8 μ).

PLATE I.

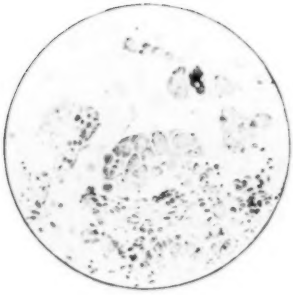


FIG. 1.

Micro-photograph of a section of a lumbar ganglion of the human fœtus at the third month. Zeiss $\frac{1}{8}$. Showing the embryonic type of cells in a colony.

in colonies of four or six. The colony, and not the individual cells, was surrounded by a capsule. At the sixth to the seventh month the commencement of the formation of types was first clearly seen. (Plate I.)

Observations similar to this have been made by Van Biervlet (14) in man, and by Dall'Isola (15) and Olmer (16) in animals.

Lugaro states that he has observed these embryonic types as constituting the normal character of the cells in the frog and the tortoise.

The type of reaction is, as shown by our figures, one of central chromatolysis, and hence there is justification for the statement originally made by Van Biervlet that the morphological characters of cells in the reactive phase are met with in cells undergoing development, and are also seen in lower forms of philogenetic development.

An interesting pathological observation by Sibelius (17) indicates that in congenital syphilis the cells of the full term fœtus also show a retardation of development as evidenced by the presence of double nucleoli, the formation of colonies, and the absence of a capsule around the individual cell.

The Cells which give Origin to Afferent Fibres in the White Rami.

It is known from physiological experiment that every white ramus contains afferent fibres. This can also be readily demonstrated by division of the spinal roots between the ganglion and cord, and subsequent examination of the ramus. If sufficient time be allowed—forty-two days or more—all the fibres derived from the spinal cord degenerate, those remaining intact must have their cells of origin in the spinal ganglia. The white ramus is then stained in 1 per cent. osmic acid, and may be examined either after teasing, or it may be embedded and cut in transverse section.

In this way Sherrington (18) determined the number of afferent fibres in the tenth thoracic white ramus of a small cat to be 150, the diameters varying from 12 μ to 1·5 μ.

In a personal communication Dr. Anderson informs us

that the twelfth thoracic ramus in a cat was found to contain 374 afferent fibres, of which forty-two were large (8 to 11 μ), seventy-five medium (6 to 8 μ), and 157 small (4 to 6 μ).

Langley and Anderson (19) found 1,100 afferent fibres out of a total of 3,500 fibres in the pelvic splanchnic or nervus

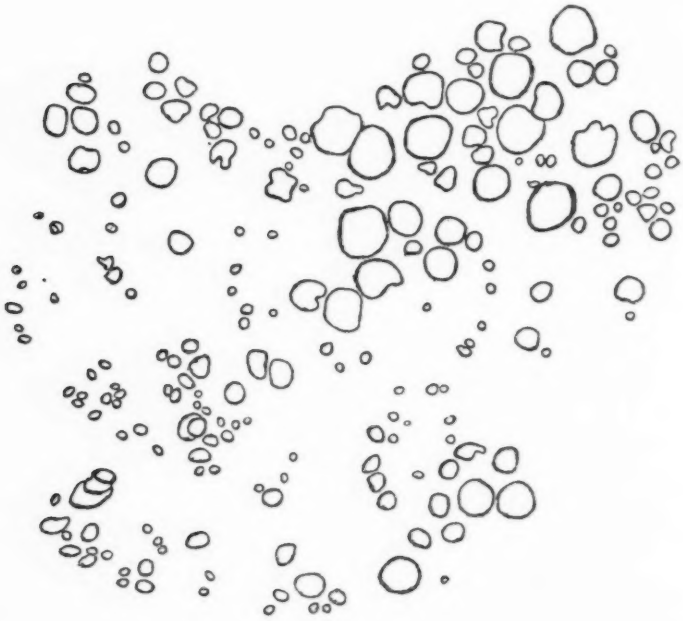


FIG. 3.

Afferent fibres of the second dorsal white ramus, which remain undegenerated 48 days after division of the anterior and posterior roots. Leitz $\frac{1}{12}$. Drawing ocular.

erigens. Similarly, after the division of the anterior and posterior roots of the first and second thoracic nerves in a cat, we allowed forty-eight days for any fibres having their cells of origin in the spinal cord to undergo complete degeneration. The white rami were then dissected out, stained in osmic acid, and cut at various levels in transverse section

(fig. 3). There were found in the first ramus 136 sound fibres—

5	with a diameter	under	2	μ
53	,,	,, between	2 to 4	μ
9	,,	,,	4 to 6	μ
27	,,	,,	6 to 8	μ
34	,,	,,	8 to 12	μ
8	,,	,,	12 to 15	μ

In the second ramus there were found 192 sound fibres—

5	with a diameter	under	2	μ
90	,,	,, between	2 to 4	μ
38	,,	,,	4 to 6	μ
32	,,	,,	6 to 8	μ
23	,,	,,	8 to 12	μ
4	,,	,,	12 to 14	μ

Thus in each case more than half the fibres are over 4 μ, which is about the maximum size to which efferent sympathetic fibres attain. With regard to the few fibres which were over 12 μ, some of these were distorted owing to the contraction of the remaining tissue of the nerve, and, as the longest diameter was measured, their real size was probably under that given. The fibres also in some cases were cut rather obliquely. This point should be mentioned as fibres over 12 μ have not previously been found in the sympathetic system.

A few additional remarks may conveniently be made here. Gaskell (20) describes and figures in the dog a communicating branch between the first and second dorsal nerves, which runs along with and in the same connective tissue sheath as the second white ramus; we did not find this condition in the cat.

Edgeworth (21) has by dissection shown that large fibres (7·2 to 9 μ) are present in all the white rami of the dog, but the number of such fibres would appear from the figures given above to be considerably more numerous than he estimated; thus he only found ten large fibres in the first dorsal ramus and fourteen in the second.

We have next to enquire as to the variety of cells in the

spinal ganglia which give origin to afferent fibres in the white rami.

We are again indebted to Dr. Anderson for the description of an operation which exposes the stellate ganglion of the thoracic chain between the heads of the first and second ribs. The operation is almost bloodless, and, beyond a little separation of the muscles attached to the scapula, involves only the teasing away of the first intercostal muscles. The ganglion and the first and second dorsal rami running to it can be seen on the pleura, and the desired lesion easily made (fig. 4). The experiments made consisted in one case of section of the second dorsal ramus, in another of a median

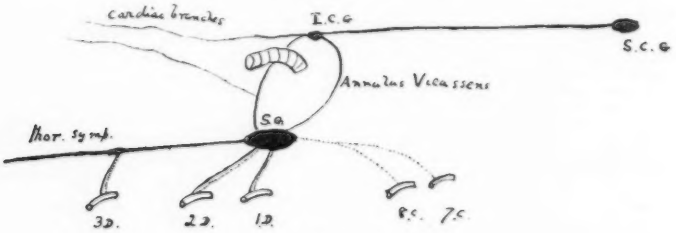


FIG. 4.

Diagram of the connections of the stellate ganglion. The three first dorsal nerves are represented with the white (continuous line) and gray (dotted line) rami, and the two lower cervical nerves with gray rami only. The other connections are indicated in the figure.

division of the stellate ganglion, and in three of its total removal. Before describing the results of these observations, it should be mentioned that a series of control experiments was made, in which the stellate ganglion was exposed but not touched, and the condition of the first, second and third spinal ganglia examined.

Briefly the results were as follows :—

Controls 1 *and* 2.

Stellate ganglion on the left side exposed but not touched. First, second and third dorsal spinal ganglia on both sides examined.

In the first experiment the three ganglia of the right side did not show any cells other than normal. On the left side the first

and third ganglia also appeared normal. In the second ganglion a series of twelve sections containing about 1,200 cells and taken at different regions of the ganglion, showed nine cells of the small dark type, in which there was eccentricity of the nucleus, with some scantiness of the central granules; in two of these cells there was an accumulation of Nissl granules around one surface of the nucleus, a feature which Lugaro has alluded to as being characteristic of chromatolysis. We also found one cell of a larger type which we were in doubt about. In the second control experiment we did not find even this small number of cells whose condition was doubtful.

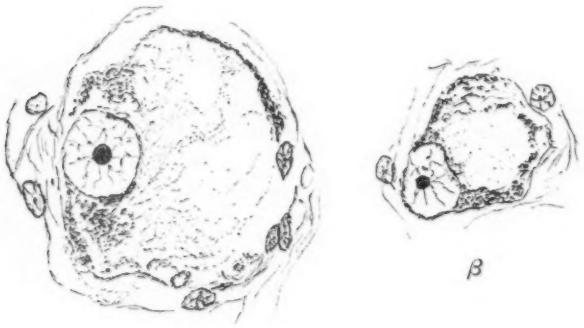


FIG. 5.

Altered cells in the second dorsal spinal ganglion after section of the corresponding rami communicantes. Leitz $\frac{1}{12}$. Drawing ocular.
(α) Clear cell (62·4 μ).
(β) Obscure cell (39·8 μ).

Control 3.

The second dorsal ramus cut, first and third spinal ganglia examined. Our note reads: "Sections remarkably well stained, all details shown. No cells can be seen which are at all comparable with those showing chromatolysis in the second spinal ganglion.

Since in the experiments following the nerve lesions, we adopted a strict criterion of chromatolysis and rejected any examples which appeared doubtful, we do not think our findings can be attributed to any other result than the nerve lesion.

Experiment 1.

Second dorsal ramus of the left side cut; condition of cells in the corresponding spinal ganglion studied.

The whole of the ganglion was cut into sections, and many of these examined.

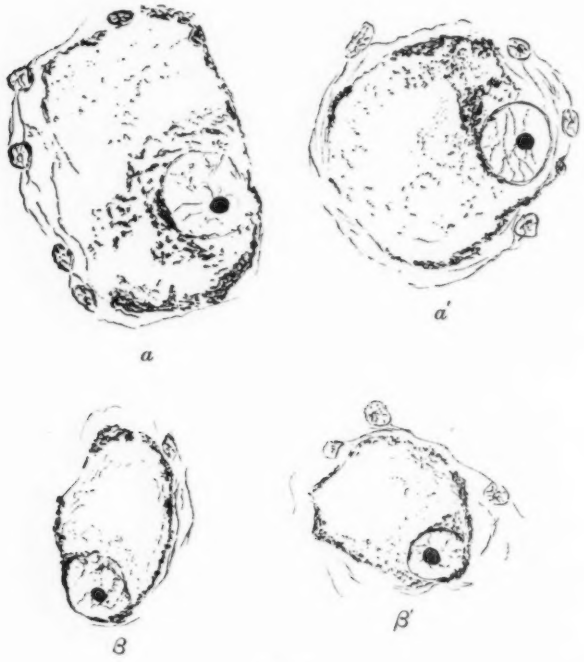


FIG. 6.

Cells showing chromatolysis in the third dorsal spinal ganglion, after lesion of the stellate ganglion. Leitz $\frac{1}{12}$. Drawing ocular.
(α) Clear cell (65 μ).
(α') Clear cell (63 μ).
(β) Obscure cell (43·8 μ).
(β') Obscure cell (37 μ).

A number of cells, being a very small percentage of the total number forming the ganglion, were found to show complete chromatolysis (fig. 5).

Of these thirty-five were measured.

6	had	a	diameter	between	50	and	55 μ
10	,,	,,	,,		40	,,	50 μ
19	,,	,,	,,		30	,,	40 μ

Experiment 2.

Central piece of stellate ganglion removed on the left side. The first to seventh dorsal ganglia were examined. Evidence of chromatolysis was found in each ganglion, as far as and including the fifth dorsal (fig. 6).

The protocols give the following figures (a section contained 70 to 100 cells).

First dorsal.—Thirty sections examined. Twenty examples of chromatolysis found; of these fourteen were small cells, six rather larger.

Second dorsal.—Twenty-five sections examined. Twenty-three examples of chromatolysis found, sixteen small cells, six rather larger, and one larger again.

Third dorsal. — Forty-five sections examined. Forty-one examples of chromatolysis found; twenty-seven small cells, twelve rather larger and two larger again.

Fourth dorsal.—Forty sections examined. Seven examples of chromatolysis; four small cells, three larger.

Fifth dorsal.—Forty-two sections examined. Three examples of chromatolysis found; two small cells, one larger.

Sixth and seventh dorsal.—These ganglia did not contain any cells showing chromatolysis.

Measurements were made of forty cells taken from different ganglia.

7	had	a	diameter	between	50	and	55 μ
14	,,	,,	,,		40	,,	50 μ
19	,,	,,	,,		30	,,	40 μ

Experiments 3, 4 *and* 5.

The stellate ganglion of the left side was removed after careful section of all its branches. The first to seventh dorsal ganglia were examined.

It is unnecessary to give the protocols of these experiments, which yielded results exactly comparable to those just cited.

Remarks.

The Wallerian degeneration has furnished unequivocal evidence that the viscera are furnished with afferent fibres,

having their cells of origin in the spinal ganglia,[1] and we have shown that the Nissl "axonal reaction" is capable of indicating these cells. Both methods show that the number of afferent fibres is small, and that the proportion of cells in the spinal ganglia thus connected with the sympathetic system is very small, perhaps barely reaching at most 2 per cent. It is not difficult to say that in our experiments nearly all the cells belong to the smaller obscure cells. This is shown by the comparison of their size and also because they can easily be recognised to undergo the features of chromatolysis, which are characteristic for that variety of cell. They do not, however, belong to the smallest type of cell, since none of those measured by us were less than 30 μ. It can also be stated that they show no features by which they can be distinguished from other small, dark cells, whose axones have a different distribution. Cells quite similar have been known to occur in all the spinal ganglia, and we shall later show that they undergo the same kind of chromatolysis after section of a cutaneous nerve. Some doubt remains as to the type to which the largest cells, those of 50 μ, belong. The smaller members of the "clear type" approach in size some of the obscure cells, and Lugaro has shown that in the condition of chromatolysis they may greatly resemble each other. Unaltered cells of the coarsely granular type could be seen in all our specimens. This cell is also present in regions of the cord which do not give origin to sympathetic fibres. It has been suspected by other observers that the small, obscure

[1] This view is accepted by British physiologists. Conclusive evidence is furnished by the fact that "after intraspinal section of a nerve just peripherally of the posterior root ganglion, either all, or all but a few, of the medullated fibres in the white rami degenerate, and that after section of the sympathetic or of the splanchnics, or of the inferior splanchnics, no degenerated fibres are present in the white rami." (Langley, "The Autonomic Nervous System," BRAIN, 1903, page 22.) It seems desirable to state this fact in view of the results obtained by Onuf and Jos. Collins (*Arch. of Neurology and Psycho-pathology*, vol. iii., 1900). In an account of their work read before the American Neurological Association, May 27, 1898, and given in the *Journ. of Nervous and Mental Diseases*, vol. 1898, page 661, these authors conclude that "most of the afferent (sensory) fibres of the sympathetic nerves do not originate from the cells of the spinal ganglia, as Köllicker claims; on the contrary, they must have, in accordance with Dogiel's view, their cell of origin within the ganglia or plexuses of the sympathetic system." In this abstract no details are given of the methods used, and we have been unable to obtain the more extensive account.

cells give origin to visceral fibres. Thus Head and Campbell (22) point out that in herpes the ganglia most affected are those in connection with white rami, and mention that such ganglia contain a larger proportion of small cells. The number of afferent visceral fibres being, however, so small, this reason cannot be an adequate one, and, further, the small, dark cells are present in all ganglia. To demonstrate the relationship direct experiment is necessary. We shall show that the large, clear cells are largely those which give origin to fibres distributed to the sensory structures of muscles, and it appears that the largest of the myelinated fibres in the sympathetic system arise from similar cells. In this connection there is the important observation of Anderson (23), who has shown that large, myelinated, splanchnic fibres develop their myelin simultaneously with large, somatic fibres, the one terminating in Pacinian bodies of the viscera and larynx, the other in Pacinian bodies, muscle spindles, and end organs connected with deep somatic structures. Similarly, the finer medullated fibres which terminate in the skin, and which are connected with pressure and painful sensations especially, are myelinated contemporaneously with the fine set of medullated, splanchnic, afferent fibres which, he argues, supply the epithelial structures of the viscera, and which would endow them with common sensibility. Our observations show also that both sets arise from a cell of similar histological structure.

Little is known of the distribution of the afferent fibres in the upper dorsal white rami. This could be ascertained by removal of the spinal ganglia, and subsequently tracing the course of the degenerated medullated fibres. We have not yet attempted this. It is known, however, that none pass into the cervical sympathetic, and clinical evidence, especially adduced by Head (24), points to their distribution to the heart and lungs. The augmentor cardiac fibres pass out by the second to the fifth anterior roots, and Head considers the sensory part of the arc is represented in the same segments, or is of wider distribution. He says that the pain attributable to pressure in the left ventricle finds itself mainly distributed to the cutaneous areas supplied by

the second and fifth dorsal nerves. Though, owing to the limitation of the method of axonal reaction, too much importance cannot be attached to the fact, it is interesting to note that the fifth dorsal spinal ganglia was the lowest in which we succeeded in finding evidence of changes after lesion of the stellate thoracic ganglion. This experiment indicates that afferent fibres arise as low as the fifth dorsal, run up the thoracic chain, and pass through the stellate ganglion and out by the annulus of Vieussens. That the annulus of Vieussens contains afferent fibres has been shown by physiological experiment by Langley (25), and Edgeworth (26) traced large fibres in it, passing with the cardiac branches of the inferior cervical ganglion. The afferent nerve to the aorta appears to be the depressor, as shown recently by Köster (27), and by Tschermak (28). Since the splanchnics receive afferent fibres as high as the fourth dorsal and perhaps higher, it would appear that the same spinal ganglion may supply both thoracic and abdominal viscera, a fact of interest in connection with the overlapping of the "sensory areas" of referred pain in diseases of the stomach and lungs (Head).

The Cells of Origin of the Afferent Fibres to Muscles.

Sherrington (29) first showed that in a muscular nerve trunk from one third to one half of the myelinated fibres are from cells of the spinal ganglion, and that their diameters varied from 2 μ to 20 μ, or that some of these fibres are a hundred times larger than others. He asks, "Does a difference at all corresponding with this exist between the sizes of the cells in the spinal ganglion?" He finds that the diameters of the cells vary from 100 μ to 20 μ, or taking the cells as of spheroidal figure, some have a volume 125 times that of others. The assumption is that large fibres arise from large cells.

We have studied the changes which take place in the spinal ganglia after section of a purely muscular nerve, viz., the hamstring nerve.

Sherrington states that the nerve in the cat contains 4,512 fibres, of which 1,456 are afferent. In three instances

we exposed the nerve at the top of the thigh, and a small piece was removed. The sixth, seventh, and eighth post

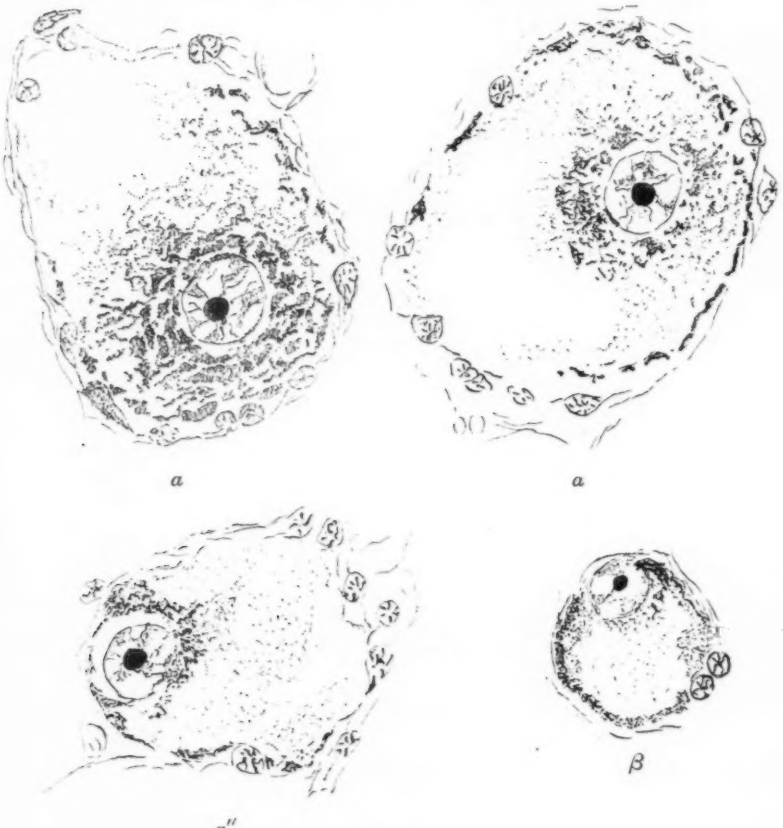


FIG. 7.

Altered cells from the seventh lumbar spinal ganglion after section of the "hamstring" nerve. Leitz $\frac{1}{12}$. Drawing ocular.
(α, α', α'') Clear cells (90·3 μ, 79·7 μ, 57·7 μ).
(β) Obscure cell (36·2 μ).

thoracic spinal ganglia were removed on the fourteenth day, and subsequently examined. Obvious chromatolysis of some cells was found in each case (fig. 7).

Of fifty cells accurately measured, the smallest was 32 μ in diameter, the largest 93·5 μ.

11	had a	diameter	between	30	and	40 μ
17	,,	,,	,,	40	,,	60 μ
14	,,	,,	,,	60	,,	80 μ
8	,,	,,	over	80 μ		

Another series gave—

65	cells	with a	diameter	over	60 μ	
43	,,	,,	,,	between	50	and 60 μ
52	,,	,,	,,	,,	30	,, 50 μ

The largest cells therefore are those in which the change is most seen, a fact to be considered in conjunction with Sherrington's statement that of the afferent muscle fibres the majority belong to the class whose diameter is 12 μ or more.

The figure shows that the large clear cells are most readily affected. All the largest and most of the medium sized cells showing chromatolysis belong to this type. The obscure cell is the other type showing change.

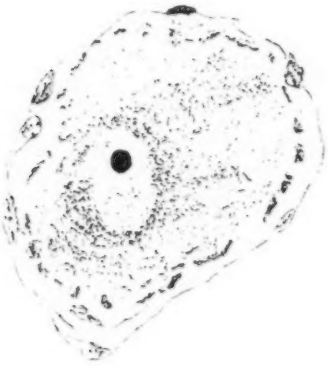
Many examples of the coarsely granular cell were noticed intact, and the smallest cells of the ganglion, viz., those up to about 25 μ, did not appear changed. From Sherrington's observations we know that only fibres of 7 μ or more are distributed to the muscle spindles, and hence the cell of origin of these is the large clear cell, the remaining cells accounting for afferent fibres to muscle structures having some other kind of end organ.

Cells of Origin of Afferent Fibres Distributed to the Skin.

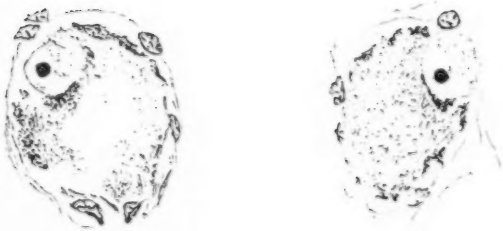
The long saphenous nerve was cut in the upper third of the thigh, and the fifth and sixth lumbar ganglia examined. In an examination of eighteen sections taken from the sixth lumbar ganglion, eighty-five altered cells were found, of which fifty-four belonged to the obscure type, thirty-one to the clear type (fig. 8).

Of forty cells accurately measured—

8	had a diameter	between	30	and	40	μ
19	,,	,,	40	,,	50	μ
5	,,	,,	50	,,	60	μ
5	,,	,,	60	,,	70	μ
3	,,	,,	70	,,	75	μ



a



β *β′*

FIG. 8.

Altered cells in the sixth lumbar spinal ganglion after section of the internal saphenous nerve in the middle of the thigh. Leitz $\frac{1}{12}$. Drawing ocular.

(*a*) Clear cell (69 μ).
(*β*, *β′*) Obscure cell (43·8 μ and 41·1 μ).

Sections of the nerve stained with osmic acid showed that the diameters of the fibres varied from 1·95 μ to 15 μ.

Here as in the preceding experiment no cell with a diameter

of under 28 μ was found altered, and the coarsely granular cell also did not seem to have been affected. The characteristic large size of the chromophile elements could not be recognised in any of the altered cells, and on the contrary many intact forms of this type were seen.

It thus appears that cells of the obscure type and those under 53 μ in diameter gave origin to the majority of the fibres, the clear cells accounting for the remaining fibres of larger size. The results are in general similar to those obtained in experiments on the visceral fibres, with the difference that a rather greater portion of fibres take origin from the clear cells.

On the Smallest Cells in the Ganglion, and on the Coarsely Granular Cells.

The Smallest Cells.

In all the preceding experiments we have been unable to find evidence of chromatolysis in cells of less than 26 μ in diameter.

These very small cells belong either to the obscure or the clear types.

What is the cause of this failure to react?

It may be suggested that since in the preceding experiments the nerves have been cut at some distance from the ganglia, the small cells do not react because they are connected with axones which leave the nerve trunk very soon. The nerves of recurrent sensibility have a short course beyond the posterior ganglion, and would escape section in the lesions made by us.

Also it must be remembered that the axonal reaction is probably more intense the nearer the lesion is made to the cells of origin.

We have therefore observed the result of a lesion immediately distal to the ganglion.

This can be done by exposing the cauda equina, and we have cut the ninth post-thoracic nerve 2 to 3 mm. beyond the ganglion.

After nine days we find evidence of alteration in the great majority of cells. The only cells remaining intact

were the smallest cells of under 26 μ. It is unlikely that in this lesion even the nerve fibres of recurrent sensibility would have escaped section.

Lugaro has performed a similar experiment, viz., division of a nerve in the cauda equina, and whilst he does not state the results of the experiment with great precision, implies that practically all the cells show change, and hence he considers that the method of axonal reaction does not support the view that there exist cells in the sensory ganglia whose axones ramify in the ganglion itself, that is, independently of the peripheral nerve.

As thus stated we cannot fully accept this conclusion. Is a small cell peculiarly resistant to damage to its axon? On the contrary, Lugaro's experience and our own is that it very readily undergoes chromatolytic change. Does the very small cell represent the multipolar or "relay" cell described by Dogiel and others? This supposition we have also to reject, chiefly on account of its small size. Dogiel's measurement gave a much greater size. We suggest the explanation is to be found in the observations of Donaldson (30) and his colleagues, to which we rather fully refer.

Hatai (31) has shown that in the white rat the number of cells in a ganglion remains constant at various periods of age from birth to adult life. Averaged from different ages, he gives the following figures as the number of cells in the ganglia of three regions: Sixth cervical, 11,140; second lumbar, 8,867; fourth thoracic, 7,306. Whilst, however, the total number of cells remains constant, both he and Donaldson agree that the relative number of large and small cells varies. With the increase in age the small cells diminish, the large ones increase. This fact they have observed in all regions. In other words, the small cells grow to become large ones. The small cells, therefore, are considered to be in an immature condition and to have no axones, and, though they may later acquire them, many remain permanently immature. Hence a distinction is made between cells in "reserve" and cells in "commission."

Two sets of facts are brought forward to support this contention. First they find that in the newly-born rat there

are in the dorsal roots immature fibres, distinguishable by the feeble staining of their myelin, and that as the animal becomes mature both the total number of root fibres increase and the proportion of immature to completely-formed fibres diminishes. Thus in the newly-born rat in the sixth cervical root they find 1,998 fibres, of which 48 per cent. are immature, whilst in the adult animal they find 4,227 fibres, of which only 1·2 per cent. are immature. Secondly, the figures given above of the number of cells in various ganglia show that there is a great excess of cells over fibres. Such excess of cells over root fibres has been previously observed by Hodge, Bühler, Gaule and Lewin, and their results are quoted by Hatai.

Our observations have all been made as the result of a peripheral lesion. Hence, assuming these figures to be correct, and the most careful methods were adopted to ensure accuracy, we have to ask if the same excess of cells exists with reference to peripheral fibres. In other words, what is the proportion of peripheral fibres to root fibres? Dale (32) in the adult cat finds they are practically equal. Holl, Freund, and Stienan also only find a slight peripheral excess. The results of Hardesty (33) indicate that the equality does not exist in all kinds of animals, as in the frog (rana virescens) he found a marked excess of peripheral over central fibres.

The result, however, of these observations of Hardesty, Donaldson, and Hatai, leads to the conclusion that the number of cells in any ganglion is in excess of the peripheral fibres, and that therefore one assumption is that all the cells of the ganglion do not give off peripheral axones.

We consider that these findings explain why the smallest cells do not give the axonal reaction. They are immature nerve cells, and have at least no fully-developed axon. We find their number to be in the second cervical, 7·6 per cent.; in the eleventh dorsal, 13·5 per cent.; and in the seventh lumbar, 13·5 per cent.

The Coarsely Granular Cell.

As stated in the preceding section, the members of the

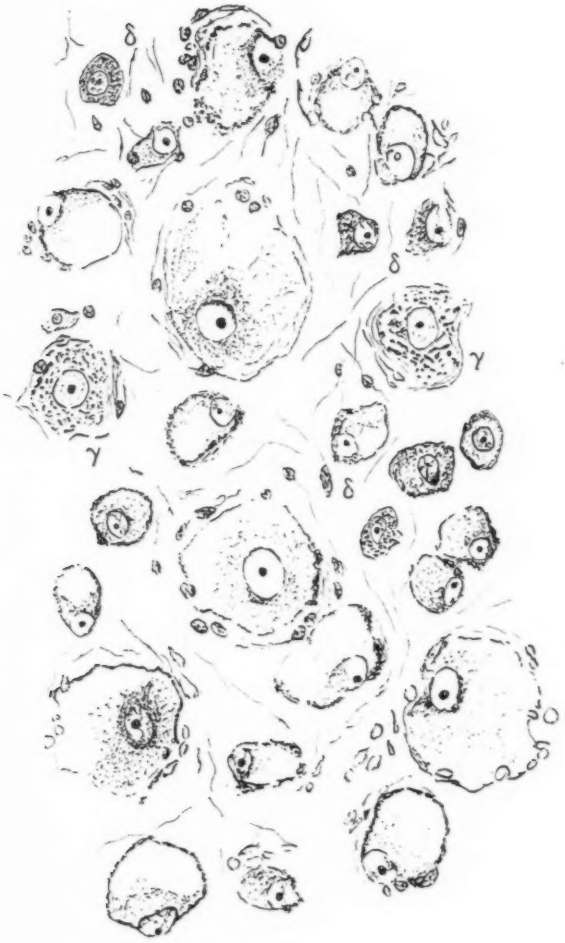


FIG. 9.

Showing cells in the first dorsal spinal ganglion after section of nerve immediately distal to the origin of the rami communicantes. All the cells drawn exhibit chromatolysis except γ coarsely granular cells and δ the smallest cells.

coarsely granular type were found intact in all experiments, except the one in which the lesion was made in the cauda equina. In this case they shared the change common to all other types except the smallest cells of the ganglion.

How resistant they are to a lesion of the peripheral nerve trunk is shown by an inspection of fig. 9, which is drawn from the first dorsal ganglion, and shows the changes following a lesion immediately distal to the origin of the sympathetic ramus. In this case all fibres peripheral to the ganglion had been cut, except the white ramus and the primary dorsal division. The resulting chromatolysis was very extensive, but intact coarsely granular cells were found as well as the smallest cells.

We have no further evidence to advance as to the significance of this cell. It is a very well-defined type, having in a great majority of instances a diameter of between 40 and 50 μ; its chromophile granules are nearly as large and discrete as those of anterior cornual cells of the spinal cord.

The negative evidence obtained points to it being not the cell of origin of fibres distributed to the skin or viscera or muscle structures.

Its great resistance to change may, perhaps, be due to its axon not extending beyond the ganglion, and hence the cell would belong to the class described by Dogiel, *i.e.*, relay cells.

It may also be mentioned that Bayliss (34) has shown that there are vaso-dilator fibres in the posterior roots, that these fibres have their cell of origin in the spinal ganglia, and that the cells belong to the ordinary class having the ⊥ axon.

Summary of Conclusions.

(1) The size of the cells in the ganglia is a function of the diameter of the nerve fibre, and the difference in appearance of the chromophile elements has a dynamical significance. These elements represent material which is used up by the essential trophoplasm, which presides over the nutrition of the nerve fibre.

(2) At the region of the limb plexuses, a number of large

cells appear in the ganglia, which are the cells of origin of the fibres to sensory muscle structures.

(3) Lugaro's classification is confirmed in the main.

The cells met with are best described as (α) clear cells; (β) obscure cells; (γ) coarsely granular cells; (δ) smallest clear cells.

(4) The large clear cell and the obscure cell give origin to the fibres distributed to the skin, viscera and muscles. Of these the largest cells are exclusively connected with fibres from the muscle spindles. Large somatic and large splanchnic fibres have origin from cells of the same type, the large clear cell; small somatic and small splanchnic fibres also from cells of the same type, the obscure cell.

(5) Afferent fibres to the thoracic viscera arise from the first five dorsal ganglia. The number of such fibres in one instance was found to be 136 in the first dorsal, 192 in the second white ramus.

(6) The smallest cells in the ganglion, under 26 μ in diameter, whether belonging to the obscure or clear type, are immature cells, and have no fully-developed axon.

(7) The coarsely granular cell is highly resistant to the axonal reaction, and may be a "relay" cell, but sufficient evidence is not forthcoming as to its significance.

(8) The cells in the early embryo have the appearance of the smallest type described in the text. In the newly-born human subject the types present in the adult can be recognised. The morphological characteristics of the cells of early embryonic life are also met with in the reactive phase.

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ON CERTAIN TREMORS IN ORGANIC CEREBRAL LESIONS.

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THERE is perhaps no symptom in neurology whose anatomical basis or the physiology of whose production is less understood than those involuntary movements which, though varying in their character and accompanying conditions, are collectively known as tremors. Their occasional association with various gross organic lesions of the central nervous system has been recognised and described for years, but, on the one hand, indefinite and incomplete clinical characterisation, and on the other unsatisfactory and often defective description of the localisation and nature of the pathological lesion, has made a study of the cases unproductive of tangible results.

Owing to the loose way in which the term tremor has been employed in the literature of the subject, it seems advisable to offer at once such a conventional definition as will serve as a basis for the more detailed description of its several characteristics. I would suggest that the term tremor be used to denote a clinical phenomenon consisting in the involuntary oscillation of any part of the body around any plane, such oscillations being either regular or irregular in rate and in amplitude, and due to the alternate action of groups of muscles and their antagonists. If such a definition be accepted it becomes obligatory in describing the symptom to note the regularity or irregularity of the range and of the rate of its component oscillations. Here, too, emphasis must be laid on the importance of detailing exactly what movements are comprised in a particular tremor. A tremor may be simple or compound; in the former case only one group of muscles and its antagonists

being involved, in the latter the resulting movement being the effect of the action of several groups and their antagonists. For instance, flexion and extension of the fingers may coincide with pronation and supination of the forearm. In such cases the study of the condition evidently resolves itself into the study of the individual simple movements.

The graphic representation of the oscillations as first employed by Gowers, or of the muscular contractions by some form of ergograph, is advisable, generally almost necessary, for a complete study of all clinical tremors, and direct tracing of the movements is when possible preferable to tambour records as being more accurate. This method has been employed in the examinations of all the cases here recorded as well as in that of a number of other cases which have been carefully studied for the purpose of contrast and comparison. When the tremor is compound it is necessary in taking a tracing to mechanically check all but the one movement which is being studied, or to adopt some device to exclude the complications introduced by other movements.

In addition to the detailed description and graphic record of the movements of which the tremor is composed, it is important to note the influence of volitional movement, of attempted voluntary inhibition, of sleep, and of psychical rest and activity.

The cases recorded in the paper presented clinical symptoms of considerable similarity, and the evidence thus afforded suggested a common site for their pathological lesions, a suggestion which was verified in the two cases examined *post mortem*. The aim of the paper is to give a concise clinical description of the cases, to ascertain from direct and indirect evidence the nature and position of the lesions, to attempt to exactly define the essential factor in the lesion, to discuss the possible pathogenesis of the tremor, and finally, to compare and, contrast the cases with identical or similar ones collected from the literature.

I must first express my indebtedness to Dr. Buzzard, Dr. Hughlings Jackson, Dr. Ferrier, Dr. Ormerod, Dr. James Taylor, and Dr. Risien Russell, for permission to use the cases I have observed under their care in the National

Hospital, and to Dr. Farquhar Buzzard for having kindly supplied me with the description of the lesions which he, as pathologist, found in the cases which were examined *post mortem*.

Case 1.—R. E., the first case observed, was a healthy-looking woman of 59 years, with an excellent family history, and no history of previous illness, who came under the care of Dr. Ormerod in July, 1903. Four months previously she suddenly and without loss of consciousness became unable to walk and found her left arm useless. She was taken to an infirmary, where she slowly regained the power of walking, but has never since been able to get about as she formerly could. She also complained of the left arm having remained "useless," though she was able to move it about quite well, that it became quite unsteady when she attempted to do anything with it, and that when even at rest it frequently shook. She had not been able to read since the onset of this condition, and has had diplopia. There was no headache, vomiting, or other symptom in the history of her illness which could raise the suspicion of cerebral tumour.

On examination her visceral organs were found normal, but her pulse tension was unnaturally high, though no other evidence of renal disease could be detected. There was no psychic impairment, but she was abnormally emotional, and frequently burst into tears or laughter without adequate cause. Her vision was fair and the visual fields were uncontracted, but she was unable to read owing to paralysis of accommodation. There was also complete paralysis of the upward movement of both eyes, and the downward movements were defective, but the range of lateral excursion and convergence remained good. There was also marked bilateral ptosis, with compensatory wrinkling of the forehead in the attempt to look up. Both pupils were inactive to light stimulation, and contracted very little and sluggishly on convergence. Since then there has been slight return of the upward movement of the left eye, but the palsy of the levators of the right remains complete. The range of downward movement is much increased; at present it is almost normal. Her face was stiff, fixed and expressionless, and there was little change of expression as she conversed, but the voluntary movements were all perfect, and the associated movements good. There was, however, very little movement as she attempted to smile, and those which occurred when she laughed or wept were slow and stiff. The speech, too, was monotonous and expressionless. The mask-like facial expres-

sion and the monotonous and toneless articulation gave to the case, as many who saw her remarked, the appearance of paralysis agitans.

When she first came under observation there was definite paresis of the left limbs, with some rigidity, brisk deep reflexes, and an extensor plantar response on the same side. The right limbs were then normal in every respect, and of good power. The left hemiparesis soon disappeared, and the plantar extensor response was replaced by one of the normal flexor type, but the slight degree of rigidity has remained unaltered.

In walking both limbs and trunk were held stiff, without any swing or play of movement; she shuffled along with short steps in an uncertain manner, and turned *en bloc*, so that her gait, though neither reeling nor ataxic, appeared affected out of all proportion to the slight impairment of power of the lower extremities. The left hand was generally held in the interosseal position, the fingers extended at the distal and partially flexed at the metacarpo-phalangeal joints, with the thumb opposed to the index finger. There was no other peculiarity in the position of the limb. The whole arm was slightly rigid; there was almost uniform and constant resistance to passive movement through its whole range. The voluntary power of the various movements was, as compared to the corresponding of the right limb, only little feebler.

Except when the limb was at perfect rest and so supported that each segment bore its own weight, there was constantly slow clonic tremor of one or other part of it, but more marked at the distal than at the proximal joints. Frequently the adducted fingers were flexed and extended at their basal joints, the index finger rubbing against the opposed thumb, which was in synchronous tremor. Often it was flexion or extension of the hand at the wrist, or flexion and extension, but more frequently pronation and supination, at the elbow. Movements were less frequently visible at the shoulder.

Similar tremor was occasionally to be observed in the left lower extremity, and, as in the arm, more frequently at the distal than at the proximal joints. It most often took the form of extension and flexion of the foot.

The character of the tremor was constant, no matter in which portion of either limb it was observed. It was remarkably regular in rate, and varied very little in amplitude, so that the movement of the limb, as long as only one group of muscles was involved, was essentially regular and rhythmical, but as more than one group was frequently at one time in action, the resultant

movement was often a compound tremor. It was slow in rate, from 2½ to 3 oscillations per second, and of considerable amplitude. (Tracing I.)

It always ceased during sleep and when the limb was allowed to lie at rest, so supported that each portion bore its own weight. If any part of the limb was allowed to hang passively (as the hand when the limb was held up by the forearm), the tremor immediately began at the most proximal joint of the unsupported portion. It was increased by any excitement or agitation on the part of the patient, and by movement of the opposite limb. The movements could only be inhibited for a very short time. Voluntary movements of the limb were complicated by wide irregularities of the intention tremor type, but there was no other affection of co-ordination. There was no alteration of any form of sensation. The patient's condition still, now fifteen months after the onset of the illness, remains practically unaltered.

Diagnosis.—The existence of such definite ocular palsies indicates disease in the mid-brain, and the sharp differentiation of the movements affected points to direct involvement of the oculo-motor nuclei, the lesion extending more to the right than to the left of the middle line. The sudden onset of the condition indicates a lesion of vascular origin.

Case 2.—A. R., a woman aged 37 years, came under the care of Dr. Ormerod in November, 1903, complaining of uselessness of the right limbs, affection of gait and double vision. Her family history and previous health were good. Four months previously she had fallen down a flight of stairs, bruising and cutting the left side of her head over her ear. She lay unconscious for two hours, and had to keep her bed for a few days. Then she noticed diplopia on looking below the horizontal, the images being one above the other. Since then, too, her right arm has been more or less useless; "she didn't seem to have the power to do anything with it;" she has not, for instance, been able to use it in dressing her children, though there was no loss or limitation of any movement. Three weeks after the accident the right upper extremity began to shake, and all its movements became very irregular. The tremulousness of this limb has gradually increased till the present.

It was a month after the accident that her walking first was affected, and since then it has rather rapidly become worse. She also complains of the right leg shaking. There have not been any aphasic symptoms associated with this right-sided affection. She spontaneously remarks that she has been very low-spirited, and has frequently wept without cause during the illness.

The patient is a dull, stupid woman, poorly educated but extremely emotional, frequently weeping without adequate or any cause, and in the same way occasionally bursting into uncontrolled laughter. Her visceral organs were normal. She occasionally suffers with headache, but there was no optic neuritis or history of vomiting.

Her distant vision was normal, but there was paralysis of accommodation of the left eye, so that she could not read with it as she formerly could. On looking up, the left eye evidently did not move so well as the right, and there was diplopia, due to weakness of both elevators. The downward movement of the left eye was also affected, and the patient had diplopia on looking below the horizontal plane.

The lateral movements were unimpared, there was no ptosis and the pupils, which were equal, reacted well to light and on accommodation. There was no appreciable difference between the two sides of the face when at rest or in voluntary movement, but in emotional expression the right side moved distinctly less than the left. Both sides of the face were, however, rather fixed and expressionless as she conversed. The musculature of the limbs was fairly well developed for a woman of her size, and the left limbs seemed normal in all respects. On the other hand there was slight rigidity and relative weakness of the right limbs, but no limitation of the range of movement. There was also a marked slowness in starting every voluntary movement, and in exerting the full possible force, which was then not well maintained.

Both right limbs were affected by tremor when they did not lie at perfect rest with their muscles completely relaxed, but it also came on when each portion of the limb was not so supported as to bear its own weight. Thus, it was rarely to be observed as the limbs lay in bed and the patient was quiet and unexcited. It might occur at any joint, but in both arm and leg was more frequent at the distal. The most constant movement was flexion and extension of the hand or of the fingers at the metacarpo-phalangeal joints, but there was also often adduction and abduction of the fingers, and occasionally the thumb might be moved against and simultaneously with the forefinger. In the leg flexion and extension of the ankle was most frequently observed, also similar movement of the toes, but various movements at the more proximal joints were often present.

The tremor was generally compound, that is, it was rarely limited to one group of muscles and their antagonists, so that the limb was as a rule simultaneously moved at two or more joints.

It never persisted for long in any group of muscles. The clonic contractions of each group of muscles involved were essentially regular in rate but relatively slow, from 3 to 3½ per second, and the range of the movements was more or less regular but considerable, *i.e.*, the tremor was slow and coarse. It ceased everywhere during sleep and was increased in amplitude but not in rate by excitement or agitation and by forcible movement of the fellow limb. The patient was unable to check it voluntarily except by allowing the limb to fall relaxed in perfect rest. There was marked intention-tremor of both right limbs, *i.e.*, abrupt deviations from the direct line of movement increasing towards the completion of the voluntary act.

When admitted to hospital she was unable to walk alone, though the strength of each lower limb was good enough to permit it, but she was soon able to get about the ward without assistance. Then she walked with short shuffling steps and body bent forward and held remarkably stiff. Though there was practically no tendency to fall, she was very reluctant to walk without support or assistance, being apparently afraid to trust her weight on her right foot, though she could to order stand on it alone for a considerable time. She did not reel or stagger or drag either foot. There were no definite sensory changes. The deep reflexes were exaggerated in the right side and extension of the great toe resulted from stimulation of the right sole.

Diagnosis.—In this case the hemiplegia alternans superior, right hemiparesis with affection of part of the left oculo-motor nerve, indicated a lesion in the left side of the mid-brain, which, from the mode of onset and course, was probably of vascular origin.

Case 3.—R. T., a strong aud robust-looking man of 21 years of age, was admitted under the care of Dr. Buzzard, in February, 1904.

His health had been excellent until eight weeks previously, since when he had suffered with intense occipital headache and vomiting, and had staggered like a drunken man, always stumbling and falling to the left. Some time later his left arm became unsteady when he tried to use it, and his sight began to deteriorate. Diplopia also developed, and he was noticed to have a squint, "the left eye turned in." He also complained of attacks of giddiness for some weeks, in which he felt inclined to fall to the left, and had the sensation of translation of objects in front of him from left to right (clockwise).

He was found on admission to be in a very weak, almost collapsed, state, and was very drowsy and inattentive, and consequently difficult to examine.

His hearing was not affected, though he complained of tinnitus in his left ear; his vision was very much deteriorated, and he had extremely intense optic neuritis evidently of considerable duration. There was complete paralysis of the left external rectus, and considerable weakness of the right. The inward and downward movements of the eye-balls were unaffected, but the upward movements of each eye were considerably limited. Coarse nystagmus resulted on lateral movements, slower and coarser in the attempt to look to the left than to the right. There was slight paresis of the left side of the face, but no interference with the functions of the other cranial nerves.

The left limbs were definitely weaker than the right, and were, in addition, wildly ataxic in voluntary movements. He was unable to walk alone, with support reeled and staggered about. All deep reflexes were absent, and plantar stimulation gave flexor responses. Sensation was not affected in any part of the body.

From these symptoms a tumour of the cerebellum, chiefly in the left lateral lobe, was diagnosed, and Sir Victor Horsley, who was called in, decided to make an attempt to remove it two days after the patient's admission to hospital. There was found to be enormous increase of the intracranial pressure, but no tumour could be found in exploring the cerebellum. As, however, the pressure suddenly fell and the brain, which was exposed, collapsed and some fluid escaped on cutting into the left lateral lobe of the cerebellum, it seemed probable that a cyst had been ruptured. The patient's condition improved very much after the operation, and most of the neuropathic signs began to disappear.

Three weeks later, however, he again became drowsy and weaker, and a new symptom slowly developed. From this time till his death, about three weeks later, there was almost constantly tremor in all four limbs. It only ceased during deep sleep, or when the muscles were quite relaxed and the limbs so supported that each segment bore its own weight. The tremor commenced at once when any of the muscles were put in tension or brought into action, as when part of either limb was allowed to hang over the edge of his bed, or when it was held up in the observer's hand. It was easily made out that the series of oscillations were due to alternate contraction of the one group of muscles and its antagonists, *i.e.*, that the movements comprised a true tremor. If the limb were left in a suitable position it seemed as if the tremor

would persist indefinitely. It was forcible and not easily checked, and showed very little tendency to overflow into other groups of muscles when passively stopped in one set. As two or more movements might simultaneously occur, the resultant movement of the limb was often compound. The upper extremities were more affected than the lower, and the left limbs very much more than the right. In the upper limbs the movements most frequently observed were flexion and extension or pronation and supination of the elbows, flexion and extension of the wrists, and flexion and extension or abduction and adduction of the fingers, which generally remained extended at interphalangeal joints. In the lower extremities flexion and extension of the ankles and similar movements of the toes were the most frequently present, but there was also often similar oscillations of the thigh round the hip joint and of the leg at the knees.

The tremor was in every part regular in rate, about five to six oscillations per second, and the rate did not seem to vary, no matter what part of any limb was affected. It may be described as coarse, *i.e.*, of large amplitude, and the range of oscillation often changed in a more or less rhythmical manner, *i.e.*, the range of successive oscillations would slowly increase to a certain point and then slowly decrease. (Tracing II.). Consequently the tremor must be described as irregular in range. He was unable to voluntarily inhibit the tremor, and its amplitude was increased by any excitement or agitation, or by forcible movement of the opposite limbs. The finer voluntary movements, too, were complicated by ataxia and irregularity of the intention-tremor type, so that he scarcely found it possible to bring his hand to his face.

With the increase of the drowsiness and general feebleness all his limbs became weaker, the left more so than the right, and at the same time rigid or rather stiff, so that they offered considerable resistance to passive movement. Some general loss of sensation on both sides of the body was also observed, and later Babinski's sign was obtained on plantar stimulation.

Some difficulty in swallowing developed towards the end, his articulation became almost unintelligible, and he slowly lost all power of movement of the eye balls. As the general weakness progressed the tremor became more feeble, yet it persisted in some degree till his death.

Diagnosis.—When the patient first came under observation there was every justification for the diagnosis of a left-sided cerebellar tumour, but the later bilateral spastic symptoms and involvement of the oculo-motor nerves pointed to extension of the growth to the mid-brain.

At the autopsy a large tumour was found lying in the dorsal half of the mid-brain which extended into the thalamus, destroying the dorsal and medial nuclei of each side in their caudal halves more extensively on the left than on the right side. There it extended a short distance into the hippocampal gyrus, but on neither side reached farther forwards than the middle commissure.

Posteriorly its end lay in and almost filled up the upper half of the fourth ventricle, and extended into and involved the left lateral lobe of the cerebellum and the neighbouring portion of the middle lobe.

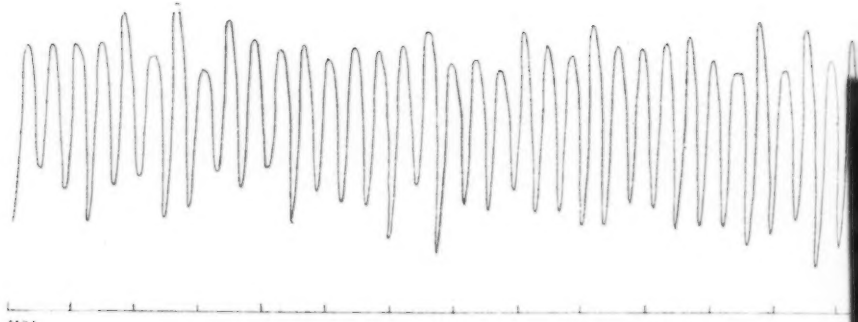
The tumour was well limited and did not infiltrate the structures neighbouring those it destroyed. It did not reach nearer than 1 cm. to the pyramidal tracts in any part of their course.

In the thalamus the internal and dorsal nuclei were alone destroyed, the ventral and lateral and the internal capsule apparently remaining intact. The greatest amount of destruction was in the mid-brain, where practically nothing remained of the tegmentum and tactal region. It seemed as though the tumour lay in the aqueduct of Sylvius and destroyed the surrounding tissues by expanding, but the pes pedunculi, though flattened out, appeared unaffected. Thus it destroyed the dorso-caudal part of each thalamus, the tectum and tegmentum of the mid-brain, including superior cerebellar peduncles and red nuclei, which were unrecognisable, and posteriorly involved the left lateral lobe of the cerebellum and the adjacent portion of the vermis.

The pons varolii, medulla oblongata and spinal cord were investigated by Marchi's method. At the level of the lower part of the pons there were very few degenerated fibres in the pyramids, but considerable degeneration marked the position of the rubro-spinal tracts. Sparse, scattered black spots indicated a slight degree of diffuse degeneration, probably pressure effect.

In the medulla there was only degeneration in the position of the rubro-spinal tracts, and in the cord some degeneration of large fibres, probably of the same origin, was visible in the lateral columns, and, in addition, degeneration in the dorsal columns of the type frequently met with in cases of cerebral tumour.

Case 4.—J. R., a boy of 6 years, was admitted under the care of Dr. Ferrier, in September, 1903. There had been gradually progressing weakness of the right limbs of three months' duration, with consequent difficulty in walking and reluctance to use the right hand. No facial weakness or



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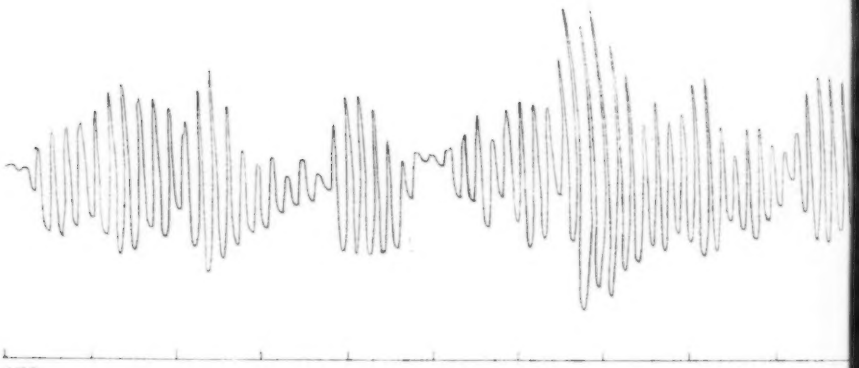

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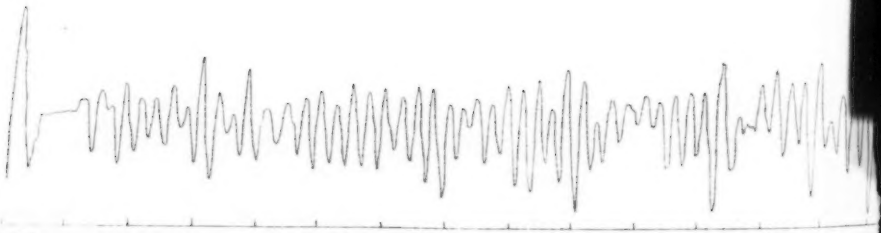

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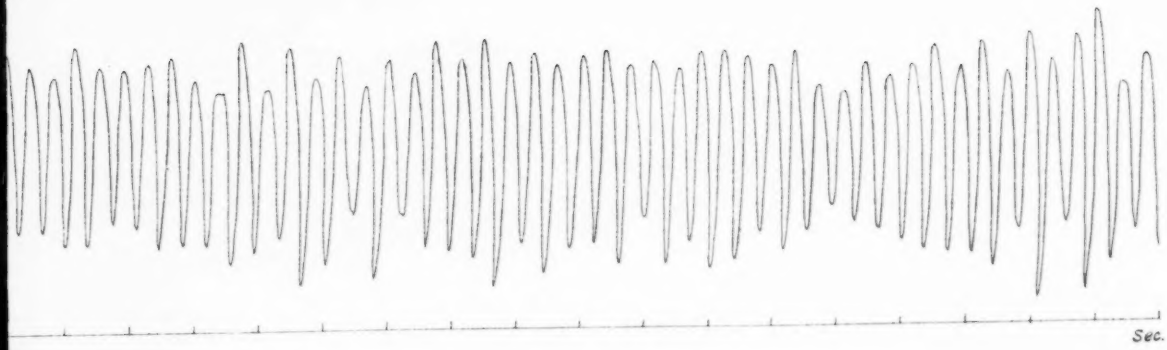

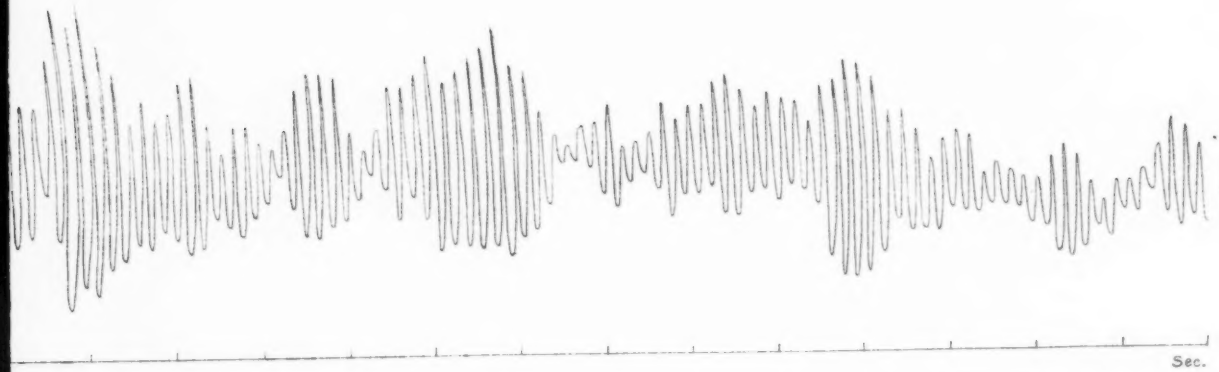

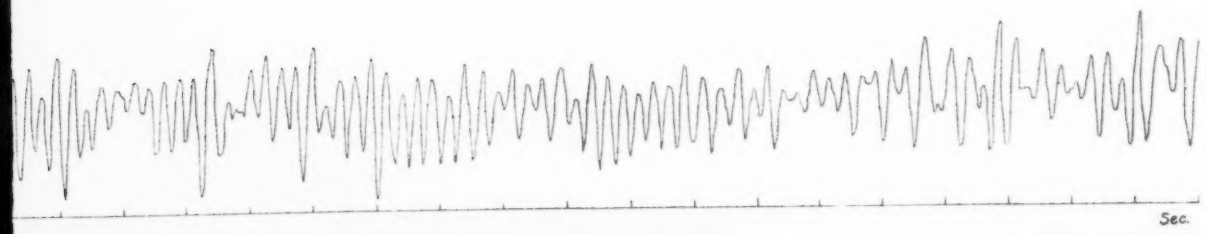

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abnormality was observed, but a squint was noticed six weeks previous to admission.

Since the weakness of the right arm became marked his mother had noticed that it was very unsteady and tremulous in voluntary movement, and that it occasionally would shake even when at rest. He had suffered much with headache, generally referred to the back of the head, and frequently vomited during the course of the illness. There had not been any affection of speech and no fits.

He was found to be a strong and healthy-looking child and bright and intelligent. His sight and visual fields were good, but intense optic neuritis was present. His head was constantly held inclined to the right and rotated to the left, so that the right occiput approached the right shoulder, while his eyes were generally in conjugate deviation to the left. It was very difficult to make him look to the right, and in so doing some weakness of the right external rectus became visible, and apparently diplopia resulted, as he tried to cover one eye with his hand. Movement of both eyes to the left was fully possible, and the vertical movements and convergence were also good, but there was coarse nystagmus on looking to the left. The pupil reflexes were normal. The right side of the face scarcely moved so fully as the left on voluntary effort, and there was some relative weakness of the right limbs but without any rigidity. All movements of the right arm were very irregular and ataxic, and some coarse and rapid tremor affecting one or any group of muscles appeared when the limb was handled or when he was asked to perform any strong movement with the left arm. The tremor was rapid: from tracings the rate seemed to be about 4 or 5 oscillations per second, and while it was limited to one group of muscles regular in range.

The distal and proximal muscles were about equally affected. The child was unable to check it voluntarily, and it was always much increased by any excitement or agitation, as when he wept. There was a slight degree of right hemianæsthesia, but the deep reflexes were about equal on the two sides, though a typical Babinski's sign was obtained on the right.

The child became drowsier while under observation, suffered considerably with headache and vomited almost daily. Within a fortnight the upward movements of both eyes were lost, and the pupillary light reaction became very slugglish, and a few days later could no longer be obtained. The right limbs also became weaker, and the above-described tremor was more frequently present. About a month after admission it began to affect the

right lower extremity. As in the arm, it always appeared or was increased when the boy was agitated, or when he moved the left limbs against resistance. The right-sided hemianæsthesia also became much more definite.

Later, the downward movements of the eyes became deficient, the upward movements completely lost, and he was no longer able to converge. The pupils remained inactive to light, and the contraction on accommodation became sluggish. The weakness of the right side of the face on voluntary movement became more marked, yet this side seemed to move the more on smiling. As the paresis of the right limbs increased, the tremor began to disappear, and finally was only to be observed when the child was very agitated, as when he sobbed or cried.

The child became weaker and more drowsy, and died about two months after admission to hospital.

Diagnosis.—The right-sided hemiplegia and hemianæsthesia, with the above-mentioned ocular symptoms, lead to the diagnosis of a lesion of the left side of the mid-brain being made, and from the general symptoms, the headache, vomiting and optic neuritis, this lesion was evidently a neoplasm.

The diagnosis was fully confirmed in the autopsy, for a small tumour, which on microscopical examination was seen to be gliomatous, was found in the left side of the mid-brain. The tumour, which was almost quite spherical and about the size of a hazel nut (1·7 cm. in cross section), lay in the lower part of the left tegmentum and largely infiltrated the left pes pedunclei at about the level of the left oculo-motor nerve, completely destroying the structures immediately dorsal to it, including the substance nigra and the nucleus ruber.

Posteriorly, dorsally, and laterally this tumour was limited by a cystic cavity which contained clear, viscid, greenish fluid. It was considerably larger in all dimensions than the tumour, and caused marked displacement of the neighbouring structures. Its effect extended posteriorly into the tegmentum of the pons and frontalwards to the posterior part of the thalamus, without, however, invading either. It practically destroyed the left corpora quadrigemina, and to a great extent also the right, but its chief effect on the various structures was merely displacement. The pons varolii, medulla oblongata and spinal cord were examined by Marchi's method, but the degeneration present was limited to the pyramidal tract and Monakow's bundle (tractus rubrospinalis) on the right side, and was relatively slight in the former. The latter followed the typical course described by Collier and

Buzzard. The amount of secondary degeneration was, as is generally the case from gliomatous tumours, remarkably small in contrast to the size of the lesion.

Case 5.—E. W., a boy of five years of age, was admitted under the care of Dr. Ferrier in December, 1903. His health previous to this illness was good, but one brother had tubercular joint disease. He was a healthy and bright child till three months before he came under observation, when he began to vomit very frequently and to suffer severe headache. A short time later it was noticed that the child was reluctant to use the right arm and limped on the right leg, and about two months from the commencement of his illness the right arm began to shake and tremble when he moved it, when it lay in any "uncomfortable position," or even at apparently perfect rest when the child was excited or agitated. This tremor, or unsteadiness of the arm, slowly increased till a few days prior to his admission to hospital. Then one day he fell down unconscious, and since then has scarcely been able to move either of the right limbs.

On examination the child was found to be bright and intelligent, his visceral organs were normal, and no evidence of tubercular disease could be detected. His sight was considerably impaired, there being intense optic neuritis, and there was right hemianopia reaching almost up to the vertical line through the fixation point. Wernicke's hemianopic pupillary reaction test was positive, that is, the pupils did not contract to rays of light thrown in from the blind halves of the visual fields.

There was slight weakness of the left external rectus, and some difficulty in the conjugate movements of both eyes to the right. Though there was no visible difference between the two sides of the face while they were at rest, there was slight weakness of the right side, practically limited to its lower half, on voluntary movement. In a spontaneous smile, on the other hand, there was practically no movements of the right side of the face, though that of the left side was free, and by contrast apparently exaggerated. Some movement of the right side occurred when the child laughed aloud, or wept, but much less than of the left side. There was no paresis of the tongue or palate, and no affection of phonation or deglutition.

The constancy with which the head was held in an unnatural position was striking. It was always to be seen slightly inclined to the right and rotated to the left, so that the right side of the occiput was approximated to the right shoulder, but voluntary movement in each direction was free and strong.

The muscles of the limbs were fairly well developed, and the strength of the left pair was relatively good and their voluntary movements well co-ordinated. When, however, the child was agitated, rather fine tremor of medium rate and regular in amplitude and rate was observed in both the left arm and leg. This was never visible when the child was composed and at rest, and as it only occurred under the above-mentioned condition, and never persisted for long, its further character could not be studied. The right arm lay quite powerless and flaccid as he first came under observation, and no tremor of any part of it was observed. The right lower extremity was also very weak, but not so severely affected as the arm. He was then unable to walk alone, and with support reeled and staggered. There was no trace of aphasia associated with this right hemiplegia, even though the boy was right-handed. There was also considerable diminution of all forms of sensation on the right side of the body, the loss of the sense of position in the right limbs being relatively the greatest. All the deep reflexes were absent, stimulation of the soles of the feet gave an extensor response on the right side, but on the left flexor.

While under observation in hospital the right limbs became more rigid and there was some return of power. The voluntary movements possible, however, were complicated by an irregularity of the intention-tremor type, and spontaneous tremor was frequently observed in the right arm when the child was in any way excited or agitated, as if abruptly wakened from sleep. He apparently had no power to check or control this tremor, which, while it lasted, was of medium rapidity—about four oscillations per second, and regular in rate. It was fairly coarse, but not quite regular in amplitude. It generally resulted from forcible movements of the opposite limb, and ceased when the child was composed and the limb lay at rest.

The presence of hemianopia with Wernicke's reaction was repeatedly confirmed, till the child finally became almost quite blind, with subsidence of the optic neuritis into atrophy.

Some weakness of the upward movement of the left eye also developed while the patient was under observation.

The voluntary paresis of the right side of the face diminished, but the defect of expressional movement became more pronounced, in fact, the right side of the face was generally described as immobile on smiling.

The deep reflexes soon returned. The patient's general condition improved and the headache and vomiting ceased. The

patient finally left hospital almost blind, unable to walk, but with fair range and power of movement of the right limbs.

Diagnosis.—This case so much resembles Case 4 that the same arguments serve to indicate the localisation of the lesion. The defective upward movement of the left eye, which developed while he was under observation, and the paresis of the right side of the face in expressional movements, tend to confirm the diagnosis of a lesion in the left side of the mid-brain.

Case 6.—F. H., a boy of 15 years of age, was admitted under the care of Dr. Ormerod, in October, 1903. He came of healthy parentage and has not had any serious illnesses. Two months previous to admission his left arm was first noticed to become weak, or "useless" as he described it, so that he could not employ it properly in his work, and he became unable to perform finer movements with it. This affection was from the first slowly progressive, and about a month or six weeks later the limb began to shake on movement or even during rest. For six weeks his gait had been affected, and his sight had not been so good as it formerly was. During the whole period of his illness he suffered very much with severe headache, and frequently "felt sick," though he rarely vomited.

On examination, hemianopia to the left extending up to the vertical line through the fixation point was found, and Wernicke's hemianopic pupillary reaction was present, *i.e.*, the pupils did not react to rays of light thrown into the eyes from the left side. There was no limitation or weakness of any of the ocular movements, and no paresis or loss of function of any of the other cranial nerves.

The muscles of the limbs and of the trunk were well developed for a boy of his age, but there was a very slight degree of rigidity of the left limbs. The left arm was very slightly weaker than the right, but the paresis of the left lower extremity was proportionately greater, indeed, practically no voluntary movement of the foot or toes was possible.

The most striking symptom of the case was the presence of involuntary movements, in the form of a tremor of the left limbs, but much more frequently and constantly observed in the upper than in the lower extremity. Neither the face nor tongue was ever affected by this, and it never spread to the right limbs. When the left arm was moved, or when it did not lie at perfect rest, each segment of the limbs supporting its own weight, there was constantly coarse tremor of one or other part of it whose rate, counted from tracings, was always about $3\frac{1}{2}$ oscillations

per second. All groups of muscles were involved, but the distal more frequently than the proximal, and in the latter the tremor was always coarser. Flexion-extension or pronation-supination of the elbow, flexion-extension of the wrist and flexion-extension of the fingers at the metacarpo-phalangeal joints, were the most frequent movements. Though more or less rhythmical the range of the oscillations was seldom constant for long, but their rate did not tend to vary. The amplitude was increased by bringing the muscles into action, or by placing the limb in such a position that they were in a state of strain, by excitement or agitation of the patient, and by strong action of the fellow limb. It only ceased during sleep, or when the limb lay at perfect rest. Voluntary movements were complicated by ataxia and irregularity of the intention-tremor type, *i.e.*, the range of deviation from the direct line increased towards the completion of the action. Similar tremor under similar conditions was occasionally observed in the lower extremity, with a predilection to the distal joints, but the voluntary movements of the limb which were possible were fairly accurately executed. His gait was only affected by the weakness of his left limb, which, as the foot could not be fully dorsi-flexed owing to weakness, was raised high to allow the toes to clear the ground, and thrown somewhat outwards as it was advanced. There was a slight degree of left-sided hemianæsthesia, tactile sensation being the most defective. The deep reflexes were increased in the left side, and the left plantar reflex was of the extensor type. His condition has remained practically unchanged since he first came under observation, excepting that the headache and general cerebral symptoms have abated.

Diagnosis.—The left hemianopia and the presence of Wernicke's reaction indicates involvement of the right optic tract before its termination in the primary optic centres, or of the quadrigeminal region, and the left-sided hemiparesis and hemianæsthesia, associated with it, points to a lesion of the right side of the mid-brain, probably by a tumour growing from its lateral surface medianwards.

Case 7.—C. S., a woman of 37 years of age, was admitted under the care of Dr. Hughlings Jackson, in September, 1903. She complained of uselessness of the right limbs and of occasional attacks of headache and vomiting. She came of tubercular stock, and her antecedent history gave rise to the suspicion of syphilitic infection.

The affection she complained of had then lasted nearly two years, and had developed slowly after a fit, which was preceded by

some vertigo. During the next week or so the right arm slowly became weaker, and about six weeks later it first became shaky and tremulous when she attempted to use it. The tremor of the right arm has slowly increased since then, and she has now for eighteen months not been able to use this limb in taking her food. She spontaneously emphasises that it is rather "uselessness" than weakness which affects this limb. She cannot pick anything up with the hand, but is able to nurse and carry her baby on this arm when she has placed him in it with the left hand.

Her gait became affected only nine months after the commencement of the illness. First the right leg felt weak and gave way under her, and soon she began to walk so unsteadily and uncertainly that she was reluctant to go out of doors lest it should be thought she was drunk. Since then she has taken very short, shuffling steps. For two months she has been troubled with difficulty in reading: the letters now run into one another and she has had double vision.

On examination, her visceral organs were found to be normal, and, though an uneducated woman, she was clear and intelligent with a good and reliable memory. She was very emotional and frequently burst into tears or laughter without adequate cause, saying she could not help it.

Her vision was good and there was no contraction of the visual fields or optic neuritis. Although she complained of diplopia there was no visible paresis of any ocular muscles, but marked nystagmus on lateral deviation, and slighter accompanying the vertical movements was present; even on fixation the eyes were unsteady. The pupils were equal and reacted well to light and on accommodation. The face seemed rather fixed and expressionless, but there was no visible paresis in voluntary movement, though in emotional expression movement was limited, slow and rather constrained. The muscles of all limbs were well developed and of good strength, with but little difference between the power of the two sides, yet it was of uselessness of the right limbs that she most complained. In the right, however, there was marked tremor of a coarse and more or less irregular character, definitely rhythmical, with frequent increase of amplitude, but from numerous tracings taken it is apparently constant in rate, about four oscillations per second. (Tracing III.). This tremor ceased during sleep and when the limb lay at perfect rest in bed, but at once commenced when she was at all excited, or even when she comes under observation, when the limb is moved about either passively or

actively, or when the muscles are in any way put in a strain, as, for instance, when the limb hangs by her side. The tremor was not so regular in the amplitude of its oscillations as that of the preceding cases, but regular, clonic contractions of one or other group of muscles might be observed persisting for a considerable time under favourable conditions. This was not at first apparent, the movements of the limb being generally irregular owing to the simultaneous presence of several tremors affecting different groups of muscles. It was a true tremor, in that it was due to the alternate contractions of one or more muscles and their antagonists, and might affect any group in the limb, but showed a preference to the distal. Voluntary movements, but especially the finer, were complicated by an accentuating tremor of the intention-tremor type, so that she was unable to use this limb in taking her meals and could not hold one finger in apposition to her nose. Similar tremor has not been observed in the lower extremity, but its voluntary movements are jerky and irregular.

Her gait was very peculiar; she advanced with slow, shuffling steps, but it was neither ataxic nor spastic, for she neither staggered nor dragged her feet, but took very short steps as though afraid to trust her weight on the right limb, consequently advancing the left foot as quickly and as short a distance as possible and in the next step unable to move the right foot fully forwards. She could stand, however, easily on either foot, and did not reel with her feet together and her eyes closed.

There was, besides, a definite degree of right hemianæsthesia, which extended up to the middle line, and a more marked loss of the sense of position in the right limbs. The deep reflexes were slightly brisker on the right than on the left side, but both plantar reflexes were of the normal flexor type. There was no trace of aphasia or other affection of speech. The patient remained about six weeks in hospital, but is still under observation. She is so far unimproved.

Diagnosis.—Even though the cardinal symptoms—headache, vomiting, and optic neuritis—were absent, there can be little doubt that in this case the lesion is a tumour which has been of very slow growth and has been, perhaps, for some time latent. The marked hemianæsthesia, with ocular symptoms and but slight hemiparesis, makes a mid-brain lesion of the opposite side probable, and this localisation is supported by the emotional state.

Case 8.—A. B., a man of 47 years of age, had been under the observation of Dr. Risien Russell for five years in the out-patient department of the hospital. His illness had a sudden onset during

sleep, six years ago. For the next three weeks he was in a dazed condition, but not unconscious, and suffered with severe headache and vomiting. From the onset he was able to move all his limbs about in bed, but noticed that the movements of the right arm and leg were weaker than they had previously been, and were, in addition, very awkward and irregular. He had no difficulty in speaking, but people were not able to understand him easily for some time. He had, however, no difficulty in swallowing. On leaving bed he found that his gait was extremely ataxic; he reeled about like a drunken man, had to learn like a child to walk again, but it rapidly improved. His right arm has remained very ataxic; he described it as "useless," recognising that he had sufficient power to move it in any way he pleased, but that he was unable to correctly regulate its movements. Besides this defect in the co-ordination of movements, he describes a trembling of the right arm which came on when he allowed it to lie in any uncomfortable position or held it up. This tremor has been most marked when he was agitated, excited, or tired. It first appeared two or three months after the beginning of his illness, and not, as the ataxia, immediately after the onset. During the first three or four months of his illness he had diplopia, especially, he thinks, on looking down, the images being separated both horizontally and vertically, and tended to cross one another. He has never had ptosis or any affection of co-ordination.

No diplopia can now be made out, but, on looking down, the left eye moved slightly less fully than the right; otherwise his vision and ocular movements were unaffected. There was a very slight degree of voluntary paresis of the right side of the face, but the difference between the two halves was more marked in expressional movements, and as he conversed he elevated only the left eyebrow. No involuntary movements have been observed on either side of his face or in tongue. There was but little difference between the strength of the right and left limbs, the former being only slightly weaker, but there was a relatively greater degree of rigidity. The voluntary movements of both right arm and leg were very irregular, the irregularity being of the type of intention-tremor. His gait is at present almost quite natural, but he says that he must be careful and slow in going up and down stairs, as the right leg trembles. Besides this intention-tremor, there was some tremor of the right arm when he held it extended in front of him or kept it in such a position that each part did not bear its own weight. The movements may occur at any joint, but more frequently at the distal than at the proximal. It only

remained a short time limited to any one group of muscles, but while it persisted was regular in rate and in amplitude, of medium rapidity, about four oscillations per second, and fairly coarse in range. He was unable to voluntarily inhibit it for any time, and on movement the intention-tremor above described appeared.

It was increased by any excitement or agitation, and constantly came on when he attempted to perform forcible actions with the left arm. It ceases when he is at perfect rest.

No affection of any form of sensation could be determined, and the reflexes were practically equal in the two sides. His gait presented no abnormal features.

There was no evidence of vascular disease, but the patient had syphilis in youth.

Diagnosis.—This rests mainly in the definite history of diplopia with vertical separation of the images, and the slight defect of downward movement of the left eye which is still apparent. These indicate a mid-brain lesion affecting part of the left oculomotor nucleus or nerve. The sudden onset of the condition suggests that it was of vascular origin.

Case 9.—J. L., a man of 57 years of age, came under the care of Dr. Risien Russell two weeks after the onset of his illness. According to his history he retired to bed one night as well as usual, but woke up at an early hour conscious that something had happened to him. On attempting to leave bed he found he was unable to stand, and though able while lying down to move his legs about, they seemed too weak, and especially the left, to bear his weight; in his own words, he "seemed to have lost control over them." He had also tingling and numbness of all four extremities, subjectively more intense on the right than on the left side of the body. There was also when he moved severe vertigo, with translation of the objects he looked at from left to right, but there was no subjective or objective auditory disturbance. When brought a drink he found he was unable to bring it to his lips, as he had also lost control of his hands, they were very unsteady, and he was unable to direct their movements accurately. His articulation was also at the time so much affected that his speech was unintelligible. He felt very ill, had severe headache and vomited persistently for the first twenty-four hours.

The more acute symptoms disappeared after the first few days, and in the course of a week or so his right limbs were again normal, his speech was quite easily intelligible, though not natural, the vertigo had ceased, and he had no longer any paræsthesia in his limbs. The weakness and uselessness of the left limbs, however,

has persisted, the arm is so unsteady that he cannot employ it in any work, and the leg so weak that he is afraid to trust his weight on it when walking.

From the onset of his illness till he came under observation he was troubled with diplopia, especially on looking down or in front as he lay in bed. He gave no history of involuntary movements of the limb, except the irregular excursions associated with voluntary movement.

On examination he was found to be a healthy-looking, well-preserved man for his years, but his arteries were tortuous and rigid, and he admitted syphilitic infection some years previously. His special senses were unaffected, but on investigation of the ocular movements, there was found to be some defect in the downward movement of the right eye and diplopia, indicating weakness of the right inferior rectus. There was no affection of the functions of the other cranial nerves.

The musculature of the limbs was fairly developed, and there was practically no difference between the strength of the right and left limbs, nor was there any rigidity on either side. All movements of both left arm and leg were, however, very ataxic, the inco-ordination closely resembling that due to unilateral cerebellar lesions, and this was equally marked in bringing his finger to his nose and in touching a foreign object. There was also a very slight degree of diadokokinesia in the left arm. His gait, which, from his own account, resembled that of a drunken man during the first fortnight of his illness, was no longer ataxic when he came under observation, but he walked with short, uncertain steps, holding the left leg too stiff and bringing the foot too forcibly to the floor. For the first few days of his stay in hospital there was slight left hemianæsthesia, but it quickly disappeared. The left deep reflexes were brisker than the right, and the left plantar reflex was of indefinite character.

His general condition, and especially his gait, improved after he came under observation; but about six weeks after the commencement of his illness a new symptom developed. This was tremor of the left upper extremity, which at first was only very occasionally to be observed, but became more frequent. It showed predilection to affection of the more proximal groups of muscles, as adduction-abduction of the shoulder, with occasional rotation, flexion-extension of the elbow; but flexion-extension of the wrist and cigarette-rolling movements of the fingers and thumb were often observed. It only came out after some movement of the limb, if this lay in a constrained position, if the patient were at

all agitated, or when he moved the right arm forcibly against resistance. It was fairly rhythmical in character, slow (about 3½-4 oscillations per second), and regular in rate, with some tendency to slow accentuation and decline of amplitude, which was otherwise regular. It never persisted for long. The patient was unable to voluntarily arrest it, and it increased on any excitement or exertion. While earlier the defect of co-ordination of the movements of the left arm was of the cerebellar type, it slowly became identical with the intention-tremor of disseminated sclerosis, so that on trying to bring a finger to the tip of his nose it would strike the nose repeatedly in the vain attempt to keep it in position.

Diagnosis.—The existence of a partial palsy of the right oculo-motor nerve, with contra-lateral limb symptoms, indicates disease of the right side of the mid-brain. The sudden onset makes a vascular lesion probable.

In this series of cases, dissimilar though they be in their general appearance and in many of their clinical characters, there is one constant symptom. This symptom is tremor, which, it will be seen from the clinical and anatomical descriptions given above, has been observed in two classes of cases, in chronic and unprogressive cases in which the lesion is probably either of vascular origin as in Cases 1, 2, 8, 9, or, for the time being, latent tumour, as in Nos. 5, 6 and 7; and in rapidly progressive and early fatal cases of intracranial neoplasm, as Cases 3 and 4. In spite of this the tremor in all cases is very similar, or at least has constantly such characteristics as will allow of it being regarded as a definite symptom and clinical entity.

In recapitulating from the history of the individual cases, it may be described as consisting in a series of involuntary oscillations of any part of a limb, due to the alternate contractions of one group of muscles and its antagonists, of slow rate, varying in rapidity from 3 to 5 oscillations per second, in all cases more or less regular in rate while limited to any one group of muscles, in some cases (1, 3, 4) absolutely so; generally coarse, *i.e.*, of large amplitude, and either quite regular in the range of amplitude, as 1, 3, 4; with a periodical rhythmical increase and decrease of the range, as 8 and 9; or irregular, as Cases 6 and 7.

In some instances there was a remarkable tendency for the tremor to persist, apparently indefinitely, limited to the one movement if the position of the limb and other conditions remained unaltered; while in other cases it would involve various groups of muscles for short periods in succession or even simultaneously, the resulting movement of the limb being in the latter case compound and irregular, as the various oscillations were not synchronous in rate or equal in range.

In every case it was found that the patient was unable to voluntarily check the movement for more than the shortest space of time, and often the attempt to inhibit it only resulted in increase or accentuation of the range. In addition to the tremor proper, which may be described as static, as it occurred independently of voluntary or reflex movement of the part, volitional movement of the limb affected was in every case complicated by an irregularity of the intention-tremor type as met with in disseminated sclerosis, that is, the range of deviation from the direct line of the movement increased as the completion of the act purposed was approached.

In no case did it persist during sleep, though in Case 3 the patient was, during the greater part of the time that it was observed, in a semi-comatose state. It also ceased when the limb involved lay at complete rest, so supported that each of its segments was individually supported. In each case the influence of gravity on its production and existence was emphasised; any part of the limb allowed to hang unsupported was in some cases invariably, in all cases frequently, affected by tremor. This would seem to point to a certain condition of tone of the muscles being essential to, or at least concerned in, its pathogenesis, and opens up an interesting field for discussion and study of the relation of the two conditions. This, however, is avoided here with the excuse that we are still too ignorant of the full nervous mechanism concerned in the production and maintenance of muscle tone to profitably allow it.

In each case, too, it was observed that the psychical state exerted considerable influence on the intensity and

character of the tremor; it always increased with any agitation or excitement of the patient, and diminished as the patient again became composed and calm. Another factor which increased the tremor was forcible movements of the opposite limb, and even the more finely co-ordinated purposeful ones. It is noteworthy that in every case it only developed some weeks after the initial onset of the illness.

Each case of this series presents other symptoms worthy of more special notice. These may be roughly, though not perhaps accurately, grouped as those associated with the symptom-complex, but not invariably present, as rigidity, paresis and uselessness of the limbs, affection of co-ordination and an emotional state; and those merely casually related or coincident, as marked loss of voluntary power, sensory disturbance, the change in the reflexes, and the affection of the ocular movements, or of the functions of other cranial nerves. At present it is only the former group which will be dealt with, as the members of the latter are chiefly of interest in determining the anatomical site of the lesions.

The rigidity presented no special character. That which is described as belonging to the symptom-complex was, in all probability, not due, as the rigidity of the usual spastic states, to involvement of the cortico-spinal tracts in the lesion, for neither the condition of the reflexes nor the general character of the limbs warranted this conclusion. Unlike the late rigidity of hemiplegia and other spastic states, it was never associated with organic contractures. It was slight in degree, and is perhaps better described as a stiffness and a constant resistance experienced in the passive movement of the limb through the whole range of the movement. This resistance was not more marked at the commencement of the movement, and remained constant through it, and in these and other particulars was dissimilar from the rigidity of spastic paralysis. Associated with it was often a marked slowness in performing, and especially in initiating, voluntary movement.

Though the patients complained of weakness and "use-

lessness" of the affected limbs, there was in several of the cases no paresis or scarcely any in contrast to the power of the normal limbs, that accompanying the onset of the condition in the vascular cases rapidly passing off and leaving no definite evidence of affection of the cortico-spinal tracts. This weakness of which they complained was then, in great part, merely subjective. In some cases it may have been due to the accompanying sensory loss, but where this explanation does not serve, as will be more fully discussed below, it is probably to be largely attributed to interference with other systems than the cortico-spinal. Being largely subjective it is perhaps best described by using the term employed by so many of the patients—"uselessness.' Further, it is to be noted that in all probability it was not entirely due to the affection of the co-ordination of the volitional movements.

The emotional state of some of the cases also deserves some attention. This was particularly marked in Cases 1, 2 and 7, and to a lesser extent in Cases 8 and 9. These patients all remarked spontaneously or to leading questions that their temperament had changed, and laid special emphasis on a troublesome tendency to burst into uncontrollable attacks of laughing or of tears without an adequate cause, and often quite irrelevantly to the situation. Indeed, this symptom appeared so frequently that it came to be of the greatest annoyance to the patients themselves and to their neighbours. Case 1 was often continually in laughter while being examined, and Case 7 was frequently found in tears, yet both on questioning denied any knowledge of the cause or reason of their states, and might assert that their frame of mind was in quite the reverse condition. The first three cases cited, however, occasionally complained of feeling very depressed and sad, admittedly without reason. On conversation they were found to be unnaturally dull and apathetic, a change which was also observed by their friends. They took little interest in their surroundings and exhibited a marked disinclination to exert themselves in any way, and they generally preferred to remain in bed than to mix with the other patients of their wards. There was also apparent

a slowness in replying to questions or carrying out any command, a tardiness in initiating thought and action. With this psychical state some of the patients, Cases 1, 2, 4, 5, 7 and 8, exhibited a corresponding corporeal symptom. This was marked, or at least definite, paresis of the expressional or emotional movements of the face while its voluntary movements were intact or only relatively slightly affected. In Cases 1, 2, 7 and 8 the face remained remarkably placid and mask-like during conversation, with scarcely a change of expression or play of emotion, except when the patients laughed or wept, and then the movements were slow, stiff and imperfectly regulated. The affection in these cases was bilateral. In Cases 4 and 5, however, it was limited to the one side of the face, that corresponding to the limbs affected, and was by force of contrast remarkably apparent. As the children's interest was engaged or when they smiled it was seen that the movement was limited to one side of the face, and yet on voluntary effort there was little or no paresis visible. The mental state described above was not present in these two cases.

The symptoms which may be regarded as merely coincident with the symptom-complex described, are chiefly of interest as indications of the localisation of the lesions in the various cases. They deserve to be briefly discussed individually.

While, as above-mentioned, the weakness and "uselessness" of the limbs of which the patients complained were more subjective than objective in several of the cases, in others there was marked motor paresis in the form of hemiplegia. Cases 4, 5 and 6 resembled in this respect ordinary hemiplegia of considerable severity, in Case 2 there was only slight relative weakness, with an extensor plantar response when she first came under observation, and in Case 3 the only definite evidence of involvement of the cortico-spinal tracts was Babinski's sign during the last few days of life, though examination of the cord failed to reveal any degeneration of the pyramidal tracts, they having probably become affected at too recent a date for secondary degeneration to have taken place. Thus, from the descriptions of the

cases, it may be seen there are two varieties of weakness, that with extensor plantar response and the other signs of organic hemiplegia, and a variety, always much less intense, without accompanying signs of organic spastic paraplegia save the rigidity above discussed.

The strange character of the gait in Cases 1, 2, and 7 was very striking. Though there was little if any weakness of either limb, each of these women was reluctant to walk alone without some support or assistance, and even with it took short, shuffling steps, advancing each foot but a little distance. Each, too, kept her body bent forwards like a prematurely old person, and held it very rigid as she walked, with the arms to her sides and not swinging with each step. In none of these cases was there any reeling or staggering. It was frequently remarked how closely the gait in each of these cases resembled that of cases of paralysis agitans. The gait of Cases 3, 4, 5 and 8 was, on the other hand, very irregular and ataxic, the patients staggered from side to side, always more to the side of the affected limbs, and reeled in the drunken way characteristic of cerebellar disease. The gait of Case 7 was only affected by the weakness of the left lower extremity, and in Case 8 it was normal when he came under observation, though he stated that for some time after the onset of his illness he reeled like a drunken man.

The hemianæsthesia, permanent or temporary, observed in six of the nine cases, was always slight in degree. In no case was there absolute loss of even light touches (with cotton-wool), but the localisation of the touches was defective, and the patient was unable to feel them so distinctly as on the normal side. The diminution of pain and temperature senses was relatively equal to the tactile loss, and as it was more pronounced on the distal portion of the extremities than proximally or on the trunk, the sense of position of the affected limbs and the recognition of the shape and form of objects placed in contact with them, were only slightly defective. Despite this relatively slight degree of sensory loss, many of the patients complained of a numbness or loss of feeling in the affected limbs, that is, of subjective loss without a corresponding degree of objective change. The

condition of the reflexes in the various cases depended on whether the pyramidal system was involved in the lesion, or remained intact. In the latter case they were normal, or only a slight relative increase of the knee-jerks could be made out.

Special attention must be directed to the ocular symptoms, as they form the chief aid to the localisation of the lesions. From the notes on the cases it is seen that all excepting No. 6 presented some defect of the ocular movements. Six of the other remaining eight cases exhibited weakness or loss of the vertical movements of the eyes—bilateral in Cases 1 and 4, unilateral in Cases 2, 5, 8 and 9. In each instance the upward movements were more affected than the downward, and the weakness was, where any difference between the two sides existed, greater in degree on the side opposite to that of the limbs affected. In Cases 1, 2 and 9 the lateral movements of the eye-balls remained intact. In Case 1 the complete loss of vertical movements while the lateral were perfect was remarkable, and in this respect was the complement of the condition met with in lower pontine destructive lesions. As in Case 8, the history of diplopia with vertical separation of the images was the only indication of a previous ocular palsy, it cannot be more fully discussed. In Cases 4 and 5 there was some weakness of the external rectus of the same side. In Case 3 palsy of both external recti was present when the patient first came under observation, and he later developed complete bilateral ophthalmoplegia. In Case 1 there was persistent absence of the pupillary reaction, and in Case 4 the reflex contraction both to light and on accommodation disappeared. In Case 1, too, there was defect in the power of accommodation of both eyes, and in Case 2 on the side opposite to the limb affection.

In Case 7 no definite ocular palsy could be made out, but there was persistent violent nystagmus on fixing as well as with lateral and vertical movements.

Homonymous hemianopia to the side of the affected limbs, with absence of the hemianopia pupillary reaction (Wernicke's test) was present in Cases 5 and 7.

From this discussion of the symptomatology of the cases

described it is necessary to turn to the consideration of the site and nature of the pathological lesions on which the symptoms are dependent. From the general similarity of these cases and the presence of a more or less identical but exceptional symptom in all, it may be assumed that the site of the disease may be practically the same in all, and, further, it may be seen that the symptoms of each case can most naturally be explained from disease of a common region in the whole series. It is proposed to argue to the site of the disease from the symptoms independently of the *post-mortem* findings in two of the cases, and only use these latter as confirmatory of the conclusions from clinical facts.

In the first place, there is in the presence of ocular palsies in a large proportion of the cases a definite indication of the site of the lesions. This palsy most frequently took the form of loss or defect of the vertical movements of the eyeballs, certainly due to disturbance or loss of the function of part of the oculo-motor nuclei or of fibres which spring from them. The fact that there was generally only paresis of the certain muscles and not indiscriminate ophthalmoplegia, points to the affection being nuclear and not a lesion of the oculo-motor nerve trunk. That there is a segmentation of the oculo-motor nuclei and probably representation of the separate ocular muscles in its various parts, has been for long recognised, but despite the work of Hensen and Völkers, Kahler and Pick, Starr, Bernheimer, Perlia, Edinger, and others, our knowledge of this representation is far from being final or complete. The view which has been hitherto most generally accepted as being at least probably approximate to the truth is that of Starr, according to whom each oculo-motor nucleus is subdivisible into segments, arranged in a lateral and medial group, in which the ocular muscles are represented from before backwards in the following order:—

Medial.	*Lateral.*
Ciliary muscle.	Sphincter iridis.
Rectus inferior.	Levator palpebræ.
Rectus internus.	Rectus superior.
	Obliquus inferior.

This result was obtained chiefly by the compilation of clinical observations. The conclusions of other authors, chiefly from experimental work, are very divergent, probably as their results were obtained from experiments on various classes of animals. Schwabe, for instance, by Nissl's method of retrograde tigrolysis, has in the rabbit localised the two elevators of the eyes, the rectus superior and obliquus inferior, in the most caudal part of the nucleus; while Bernheimer, employing the same method in the ape, came to the conclusion that the arrangement of the central representation of the muscles from before backwards is levator palpebræ, rectus superior, obliquus inferior, rectus inferior and trochlearis, with the rectus internus and the intrinsic muscles of the globes supplied by the medial group of cells. The divergence of these views is so great that none can be applied to man without further evidence and confirmation than we now have. Bernheimer's results, as obtained in the ape, would, *a priori*, be the most probably correct, and clinical observations, chiefly personal, tend to support the representation of the elevators of the eye-balls, rectus superior and obliquus inferior, most anteriorly, and the fact that isolated lesions may paralyse the depressors together, and they alone, points to the representation of the rectus inferior in the caudal end of the oculo-motor nucleus in the proximity of the trochlear nucleus. But, as in my Case 1, the vertical movements were at one time quite lost, though the lateral were unaffected, it is difficult to accept Bernheimer's localisation of the cells of the rectus internus, intermediate between those of the elevators and depressors, especially as the lesion must have been bilateral. Clinical observations make it probable that the centre of the elevators lies close to that of the pupillary reflex arc in man, as paralysis of the upward movements was frequently associated with inactive pupils.

In this discussion it is of course assumed that there is no lower co-ordinating centre for the vertical movements of the eyes as there is for the lateral. Of this there is, as far as my knowledge extends, no direct evidence, though from analogy the existence of such seems probable.

From this consideration of the question, it must be

concluded that we are not yet in a position to deduce from paresis of any one ocular muscle a lesion in any definite position of the oculo-motor nucleus, owing to the incompleteness of our knowledge.

The affection of accommodation and the pupillary reflexes is explicable, whatever be the level of representation of the vertical movements, as it seems probable that the intrinsic ocular muscles are supplied from the medial group of cells of the oculo-motor nuclei, though perhaps indirectly through the ciliary ganglia (Bernheimer, Bach, Marina and others).

It is unsafe to assume a destructive lesion of the abduceus nucleus or nerve from slight palsy of the external rectus in cases of tumour, as from its long course the nerve is very liable to suffer from indirect pressure effects, as in Case 5, but the bilateral external rectus palsy in Case 3 was evidently a direct result of the lesion, the tumour extending into the fourth ventricle and compressing its floor. With the defect of the conjugate lateral movements, as in Cases 4 and 5, it is different. This, it is known, may result from a lesion of the lower co-ordinating centre of the movement—Deiter's nucleus, or of the fibres which leave it, dorsal longitudinal bundle, or, secondly, of the system of cortical origin which bears the volitional impulses for the movement. Monakow represents this tract as passing through the anterior part of the mid-brain in the formatio reticularis ventro-lateral to the aqueduct, lateral to the oculo-motor nucleus and at about the same level as it. In Case 4 it was evidently, from the autopsy, to affection of this system above its decussation that the defect was due, and the same is probably true in Case 5, as there was no clinical indication of a lower pontine lesion.

The hemianopia present in Cases 5 and 6 allows an accurate localisation of the lesion, as the presence of Wernicke's sign, inactivity of the pupil to rays of light thrown in from the blind portions of the visual field, makes it necessary to postulate a lesion of the one optic tract on the base of the brain, or at its termination in the quadrigeminal region in the primary optic centres. In each case, however, the associated symptoms pointed to the latter site, and

makes it very probable that the tumour was situated in the anterior tectal portion of the mid-brain.

Another symptom in some of the cases, the localisation of whose cause is of interest, was the defect of expressional or emotional movement of one or both sides of the face without a corresponding degree of volitional paresis. It is a symptom first described by Nothnagel and since extensively studied of Bechterew, Bruns and others, and has been by all ascribed to disease of the optic thalamus, probably in its caudal end, or of an efferent tract from it to the facial nucleus. The course of this thalamo-facial connection has not yet been described, but it seems probable that it passes through the mid-brain near the raphe, as the tract of each side must lie close together to be affected by such presumably small lesions, as in Cases 1, 2 and 7. Borst, on the other hand, thinks it probable that this psycho-reflex facial tract passes through the lateral part of the tegmentum, but he does not offer any definite positive evidence in support of his view. The bilaterality in these three cases makes it probable, apart from the other symptoms, that the disease does not lie in the thalamus, but interrupts the connection of the latter with the facial nucleus, and in Cases 4 and 5, where the phenomenon was unilateral, the associated symptoms pointed to the same localisation; in Case 4 this was verified *post mortem*. The psychical state of Cases 1, 2 and 7, associated with this defect of emotional display, where there was no evidence of cortical or subcortical affection, is of interest from the psychological standpoint.

The slight degree of hemiplegia present in some of the cases could not be used as a sign in the localisation of the lesions, but its association with sensory loss, evidently not of the cortical type, points to the disease being situated below the basal ganglia, where motor and sensory tracts run in close proximity.

From these symptoms the conclusion may be drawn that the site of the lesion in each case, in some with as absolute certainty as we can attain in clinical medicine, in others less definitely indicated, is in the mid-brain, possibly in some cases extending into the posterior part of the optic thalamus.

Further, the relative escape of the cortico-spinal system indicates that the disease is limited more or less sharply, in several of the cases, to the dorsal or tegmental portion of the mid-brain.

In some of the cases (1, 2, 8 and 9) the ocular palsies indicated that it was evidently of small extent and lay close beneath the aqueduct of Sylvius, at a level corresponding to a circumscribed part of the oculo-motor nuclei. When hemiplegia of any degree and ocular palsies were together present they comprised Weber's syndrome or hemiplegia alternans superior, the cranial nerve symptom being on the side opposite to the hemiplegia. In other cases instead of ocular palsies there was homonymous hemianopia, indicating involvement of the anterior end of the mid-brain and a more lateral position of the lesion. The autopsies in Cases 3 and 4 confirmed this diagnosis and localisation, as in the latter case the tumour was limited to the region indicated, and in the former its chief mechanical and destructive effect was exerted at the same level. In Case 7 there is less definite evidence of the site of the disease, but the persistent nystagmus and the history of diplopia make it at least probable that the same region was affected as in the other cases.

In studying the pathogenesis of the tremor, the symptom common to the series of cases in which our interest is at present centred, it is necessary to determine as far as possible the essential and constant factor in the lesions concerned. This may offer considerable difficulty, for the mid-brain, besides being as it were a bridge between the fore-brain and the lower receptive and effective centres and the structure through which the impulses afferent and efferent which functionate in our ordinary existence pass, contains certain structures of its own, and sends efferent tracts to the cord, while some of its nuclei are links in the systems connecting the higher and lower centres.

But if this tremor is regarded as a symptom peculiar to or dependent on a lesion of this region, as seems probable from its association in the above series of cases and in several others which have been collected from literature, it is necessary to connect or correlate it with affection of some

one portion of this part of the brain. The conclusion has already been drawn that in each of the series of cases here presented a focus of disease occupied or involved the dorsal or tegmental portion of the mid-brain. Of the structures contained in it to whose involvement the tremor may be ascribed, it is natural to first come to the consideration of the large nucleus which occupies its ventral and mesial part, and the ascending and descending systems in connection with it. This is the nucleus ruber, whose structure and anatomical relations and connections have become fairly accurately known of recent years. Developmentally it is a portion of the thalamencephalon, and its anterior end projects within the usual anatomical limits of the thalamus, while caudally it extends so far into the mid-brain that the roots of the oculo-motor nerves pass through or in close relation to it. As it thus lies ventral to the oculo-motor nuclei, and in close relation to the roots of the nerve, it seems probable, from the frequency of ocular palsies in the series of cases, that it must have suffered in the lesions, and that its damage may be the essential factor in the causation of the tremor. As is known the greater bulk of the superior peduncles of the cerebellum end in or around it, their fibres being in great part a system efferent from the cerebellum, and as they decussate before they reach it its relation to the lateral lobes of the cerebellum is crossed.

Any direct connection of the superior cerebellar peduncles with the fore-brain cortex may, with considerable certainty, be excluded, though Monakow believes that there is an indirect relation through the gray matter of the tegmentum, and possibly, too, through that of the basal ganglia. The nucleus ruber, according to the same author and others, has, in relation to its size and in comparison with the other nuclei of the thalamencephalon, but little connection with the cortex. Secondary change could be found in it only after lesions of the opercular region in man, and then in the form of slight atrophy of the ground substance while its cells remained normal, so the connection must be efferent from the cortex. On the other hand, each nucleus ruber sends fibres caudalwards to the cord—tractus rubro-spina-

lis (Monakow's bundle), and as these decussate almost immediately after their origin, each nucleus is in connection with the contra-lateral half of the cord. From these facts each nucleus ruber stands in relation to the opposite lobe of the cerebellum, the opposite side of the cord and to the homolateral optic thalamus, and possibly to the other basal fore-brain ganglia, and through them indirectly to the pallium of the same side. In this way quite apart from its cerebral connections it forms a limb in a system which connects each lateral lobe of the cerebellum with the same side of the spinal cord. This may be known as the cerebello-rubro-spinal system. From phylogenetic grounds it is presumably of considerable importance, and from its anatomical relations it cannot but be of physiological significance, as it comprises the chief efferent cerebellar system and is one of the most definite and direct routes by which the cerebellum may influence the lower motor centres as well as the fore-brain. It seems from anatomical and other considerations that it is to some involvement of this system that the tremor above described is to be attributed. The arguments in favour of this view may be stated as:—

Firstly.—The clinical symptoms of my cases make probable, and the cases which came to autopsy confirmed, an involvement of either the superior cerebellar peduncle, or of the red nucleus. Further, in a large number of cases collected from the literature, in which the localisation of the disease was confirmed by microscopical examination, either of these structures was involved. In some of these cases the lesions were more or less accurately limited to the involvement of these parts.

Then, too, in cases of destruction of the portions of the mid-brain other than that containing the cerebello-rubral system, no such tremor has been observed. This statement can easily be fully substantiated from personal observation as well as from cases published.

Secondly.—The character of the tremor and the conditions of its existence seem to be identical or closely similar to the tremor described by Ferrier and Turner, as resulting from section of the superior cerebellar peduncle of the same

side in apes (Macacus.) The descriptions of the authors are, "except when quite at rest, a constant tremor was observed in the homolateral arm and leg, which passed into larger oscillations on volitional effort"; "the limbs were the subjects of fine tremors which became greatly amplified on exertion."

Strongly in favour of this view that this tremor was directly the result of lesions of the first link of the cerebello-rubral system is the fact that they were homolateral to the injury, while, when the nucleus ruber was involved, *i.e.*, above the decussation of the peduncles, as in the clinical cases cited, it was contralateral to the lesion.

Thirdly.—It seems to me probable that such tremor may result from interruption of the final link of this system, that is, of the tractus rubro-spinalis. In a brain which I had the opportunity of examining anatomically, a small tubercular focus destroyed this tract in about the middle of the pons, and it alone. No definite clinical history of this case was obtainable, as the patient, I believe, only came under observation when moribund from hæmoptysis; but he was said to have had for some time tremor of the limbs of the same side. Such an indefinite fact, however, cannot be used as serious argument in support of the view expressed, especially as nothing is known of the character of the tremor.

Of greater importance is a case which has been under the care of Dr. Ormerod in the National Hospital. He was a boy of 17 years of age, who presented unmistakable signs of a tumour in the right half of the lower part of the pons varoli, *i.e.*, left hemiplegia and hemianæsthesia, paralysis of the right external rectus, later of the left in addition, and finally of the lateral conjugate movements of the eyes; complete flaccid palsy of the right half of the face and progressive deafness on the same side. The power of the right limbs remained good, but a few days before death they presented slow rhythmical tremor similar to that in the cases above described. The autopsy verified the diagnosis, and the appearance of the tremor was explained by recent degeneration of the right rubro-spinal tract, visible by Marchi's method. Here it may be observed that as both the superior cerebellar peduncles and Monakow's bundles decussate in the neighbourhood of the red nucleus, the one before entering it, the other after leaving it,

the tremor, if due to an affection of the cerebello-rubro-spinal system must be homolateral to the lesion if this be situated caudal to the decussations, as was so in the case just mentioned.

Fourthly.—If the tremor be due to a lesion of the cerebello-rubro-spinal system in any part of it, it should be associated with a homolateral lesion of the superior cerebellar peduncle or of the origin of this in the nucleus dentatus of the cerebellum, as Ferrier and Turner described it in the ape. As no such case has come under personal observation it may be permissible to cite one from the literature to complete the study. Sander has published a case in which the right limbs were constantly the seat during voluntary rest of a "coarse oscillatory movement and of intention tremor, quite unlike cerebellar inco-ordination, or voluntary action." Further, there was weakness of the left limbs, and the gait was reeling. In the autopsy a tumour was found in the right lobe of the cerebellum, compressing the same side of the pons and destroying the nucleus dentatus and superior cerebellar peduncle. Touche and others have published similar cases.

This case, then, is consistent with the hypothesis raised in this paper, and illustrates the association of tremor and disorder of co-ordination of the limbs of the one side with motor weakness of the opposite limbs.

If it be then admitted that the tremor as described is or may be due to an involvement of the nucleus ruber, or if some part of the rubro-spinal system, it next becomes necessary to consider its pathogenesis, the mode of its causation. In this attempt it is first essential to decide whether the lesions are to be regarded as negative or as positive, whether the symptom is the result of the merely destructive lesion of the part or of an irritative effect the lesion may have.

Either of these alternatives may be considered possible when the affection is the result of a tumour or growth, either progressive or for the time being latent, but in several of the cases where the pathological condition was in all probability due to a vascular lesion and the symptom persisted for long after its onset, it is extremely improbable that this continued to act as an irritative focus giving rise to positive symptoms. This being so in several of the cases it must be assumed

from the similarity of the symptom in all, that it is to a destructive effect on the parts concerned that the tremor is to be attributed.

But as negative lesions cannot directly produce positive symptoms, other centres or parts of the central nervous system must be concerned in the genesis of the tremor, and a full consideration of the symptom leads us to the determination of these centres to whose abnormal activity the symptom may be directly due.

As in man the fore-brain cortex and the efferent tracts which leave it to pass to lower centres are so directly concerned in the maintenance of the normal condition of the peripheral motor system, and as this is affected by each slight modification, either structural or functional, of the cortex and its connections, it is justifiable first to consider if the latter may be, or may contain, the mechanism to whose over-activity or to the perversion of whose function the super-positive symptom of tremor is directly due.

The same argument has been accepted by various authors who have contributed to the discussion of this or of similar symptoms, and has been supported by a considerable array of facts. It has been especially emphasised by Massalongo. The probability that it is to such over-action that the physiology of the tremor is to be attributed is strengthened by certain deductions, apparently natural and logical, from the symptomatology of the cases described.

Thus in the *first place* the tremor was in every case observed to cease during relative cortical inactivity, as in sleep and during perfect rest of the part involved by it. If not to be regarded a necessary result, it is at least a natural corollary to the association of the involuntary movements with the over-action of any centre, that they should vary in degree or even bear a definite relation to the normal activity of the latter. For, in considering disease, it is necessary to assume that unnatural activity or function of any organ varies only in quantity or quality from the natural, and is not different in kind.

Secondly, the converse of this was present in each case, *i.e.*, the tremor increased with cortical activity, in psychical,

as with any excitement or agitation of the patient, and in volitional, as in discharge of motor impulses. In the latter case the increase or accentuation of the symptom coincided not only with volitional discharge from the areas of central representation of the limbs affected, but also with movement of the opposite limbs, provided that it was sufficiently forcible, which may be interpreted in the result of the overflow or diffusion of normal discharges.

Thirdly, the tremor could in no case be controlled by volition, and frequently only increased with the attempt. On the other hand, were it the result of the over-action of a lower centre, it seems probable that the dominant system of our nervous organisation should have at least some power to inhibit it.

Finally, it was indicated in each case that there was no direct involvement or only relatively slight affection of the cortico-spinal tracts, and, further, as in Case 4, the tremor ceased as the hemiplegia increased. This fact in conjunction with the absence of such tremor in cases in which there has been any extensive destruction of the pyramidal system, even though the site of the lesion be the same as in the cases above recorded, makes it probable that for its appearance it is necessary that the cortico-spinal system should be relatively intact.

If it be then admitted that these tremors are due to cortical over-action, secondary to a lesion of the cerebello-rubral system, it must be assumed that, under natural conditions, the latter structure exerts an inhibitory influence in the former. Thus the final question arises as to whether this inhibitory function is normally exerted on the higher or on the lower motor centres, on the cortex or on the spinal cord; whether the cortical influence is regulated or modified at its point of origin, or inhibited and co-ordinated as it acts upon the spinal centres? There is not sufficient evidence available to definitely decide this question, but the two cases above cited, in which the rubro-spinal tract was interrupted below its origin, point to the probability of the latter alternative; but neither case is free from objection, as in the one the lesion was extensive, and in the other the clinical character of the symptom was not definitely ascertained.

If the other alternative is accepted, that is, that the inhibitory action of the cerebello-rubral system is exerted on the cortex, possibly through intermediary of the optic thalamus or other basal ganglia, the tremor should also result from a lesion of these parts or of the cerebralward continuation or connection of the superior cerebellar peduncle or nucleus ruber. As my clinical material does not include any such case, the question must be considered from any evidence to be obtained from the literature.

Apart from this, it may be finally concluded from the cases personally observed and above described, that tremor of the character found in these cases is the result of disturbance of the functional equilibrium of cerebellum and cerebrum, which is normally maintained by efferent impulses from the cerebellum, leaving it by its superior peduncle. It seems probable, too, that when its character is recognised it may be used as a clinical sign in the diagnosis and localisation of cerebral lesions. Too much importance must not, however, be attached to its absence or to variations in its character, for if it be, as it is assumed to be, due to a disturbance of a physiological equilibrium, there is much room for the play of other factors, according to the extent and nature of the lesion.

The close resemblance the symptoms of some of these cases bear to the classical symptomatology of paralysis agitans is at once evident. There is the same tremor during rest, regular or irregular in the time and space of its oscillations, slow in rate, and, as in many cases of paralysis agitans, it is intensified on the voluntary movement of the limb affected. A certain degree of paresis and marked rigidity, neither, however, due, in all probability, to disease of the cortico-spinal system, also formed part of the symptom-complex. In some of the cases there was the same mask-like expression, due to fixity rather than to obliteration of the facial lines, a similar rigidity of the whole body in progression, and a gait of short, shuffling steps, without, however, a tendency to propulsion or retrogression.

Other authors have drawn attention to this resemblance in publishing their cases. Raymond, for instance, remarks

on "Un aspect général de raideur, de soudure, d'immobilité dans l'attitude qui rapelle un peu le facies de la paralysie agitante." This resemblance was so pronounced in a few of my cases that it leads to consideration of the question whether there can be any relation between the origin of the two conditions. As hitherto little has been discovered of the pathology of paralysis agitans, it is rash to go to hypotheses, even though there be so strong a similarity in their component symptoms, but it seems permissible to suggest the possibility of the pathology of paralysis agitans being some disease of the cerebello-rubral system. I would venture to suggest the possibility of its site being in the red nucleus, and that it consists in a slow and chronic sclerosis secondary to a vascular condition. In the first place, paralysis agitans appears as a rule in older patients, in whom there is often some degree of arterio-sclerotic disease, and experience in our *post-mortem* rooms teaches that is impossible to exclude such change in the cerebral vessels from absence of any evidence of it elsewhere. The larger arteries at the base of the brain, and especially the basilar, from which the blood supply of this region comes, are known to be particularly liable to it and to suffer often the most severely when it is general. Nor is it needful to postulate a local arterio-sclerosis, for, as the nucleus ruber is one of the most vascular portions of the central nervous system, it can be assumed that for its function a liberal supply of blood is necessary, and that consequently it would suffer the most in any general reduction of the same. Should this suggestion prove correct, the sudden onset and exacerbations of the symptoms in many cases would be intelligible, and their occasional association with shocks, moral or physical, or other conditions which may modify or act on the cerebral circulation.

A full review of the literature on such conditions as the above or of closely-allied states, is at the same time very difficult and more or less unpromising of profitable results. This is chiefly by reason of the fact that there has hitherto been but little attempt to distinguish between or classify the various forms of disorders of movement which have been recognised and described, and it is scarcely possible now, as

in a large proportion of the published cases there is no accurate description of the clinical observations, many of the authors being contented with describing what they observed merely by a conventional term, or even in unconventional nomenclature. This is more or less pardonable, as there is admittedly nothing more difficult than to accurately convey by description movements observed, but the result is that this absence of accurate and systematic description makes it almost impossible to utilise in a scientific study the large material which has accumulated during the last thirty years As an instance of this may be mentioned the evident variety of conditions to which the name athetosis has been attached, and undoubtedly as large and dissimilar a series of cases has been included under the term chorea. The earlier authors included various forms of involuntary movement under some generic title, and subsequent observers have frequently been content to make some such title the diagnosis of their condition, without devoting themselves to a full clinical and anatomical study of their cases, and a scientific correlation of their results.

Post-hemiplegic chorea has been a favourite generic name for the several varieties of the symptom, but more preferable, as less binding, is the term post-hemiplegic disorders of movements, suggested by Gowers. Yet this term, too, as that proposed by Wier-Mitchell—post-paralytic chorea—is inexact and unsuitable in a certain proportion of the cases, as the involuntary movements may precede any paralysis, or may never be associated with such, nor does it express the spontaneous nature of the movements.

Yet there is such evident difference between choreoid, athetotic, tremulous and other varieties of involuntary movements when they are analysed, that it seems warranted to rigidly separate them in clinical study, and to assume that they must be due to, or constantly associated with, lesions different in nature or site. It will be seen that the definition of tremor I have adopted excludes the voluntary movements which characterise chorea, myoclonus, the classical athetosis of Hammond, and spasmodic movements due to cortical discharge (Jacksonian fits), as in none of these is there a close

succession of alternate contractions of one group of muscles and its antagonists.

Physiologically, too, the class of involuntary movements under consideration seems to differ from these others in there being at least a low degree of co-ordination or regulation of the muscle contractions, which is not to be observed in choreic, myoclonic, or Jacksonian spasms. The mobile spasms of true athetosis may, perhaps, be regarded as to some extent co-ordinated movements, but it needs little argument to show that even if related in causation or origin, they differ so much in effect that the one form must be considered at least an essential modification of the other.

There has been much speculation as to the nature of their pathogenesis. Almost the earliest attempts were to associate their appearance with some affection of the cortico-spinal system—either positive, *i.e.*, irritative, as Kahler and Pick, or negative, as Charcot, Bidon, Kolish, and the majority of the subsequent French observers. This view was also put forward by Sharkey in the Gulstonian lectures of 1886. According to Kahler and Pick, the lesion, or some part of it, lies near the pyramidal system and directly irritates it. On the other hand, those who have regarded a destructive lesion of the pyramidal system the essential condition, the involuntary movements may be either an early expression of a progressive lesion (Sharkey); or may be the permanent result of fully-developed or retrogressive disease, which, however, has been only partial (Bidon, Charcot); or may be the direct result of the consequent lateral sclerosis, as Charcot at one time held. On the hypothesis of Rendu and Gombault, involuntary movements occur when the tracts are incompletely destroyed, or compressed in such a way as to hinder the regular and continuous transmission of motor impulses, without completely interrupting them. Owing to this resistance there is an accumulation of energy central to it which can only from time to time break through it, so that the voluntary impulses reach the lower motor centres intermittently, and not, as under normal conditions, continuously.

Similarly Eulenberg and others, and especially Massa-

longs, regard the involuntary movements as of purely cortical origin, and Demange has published a case which has seemingly supported this view. The later authors have recognised that neither of these theories are compatible with facts in a certain proportion of the cases, and the greater knowledge of to-day, attained by the very large number of cases which have been published, allow an emphatic refutation of them.

In the first place, in many of the cases which have been examined anatomically the lesion has not lain in the proximity of, or involved any part of, the cortico-spinal system; then lesions which fulfil these conditions are frequent, while post-paralytic disorders of movement are relatively rare. Such symptoms, too, have been found practically only in disease of the region extending from the internal capsule to the upper margin of the pons, while, as the pyramidal tracts are identical in constitution throughout their whole length, an injury to them in the bulb or spinal cord should produce the same symptoms as elsewhere. Then in a considerable proportion of the cases there has been at no time such definite voluntary paralysis as accompanies lesions of the pyramidal system. These spontaneous movements are also unlike those which result from affection of the cortico-spinal system, and in certain cases (where the disease has been in the mid-brain or cerebellum) this symptom has been homolateral with the lesion.

One of the first attempts to connect the symptom with any circumscribed region was made by Charcot, who assumed that there is in the posterior limb of the internal capsule, in front of the sensory system, a layer of fibres with peculiar motor functions, whose disease leads to hemichorea. This view was later adopted by Raymond and Brissaud. The fact, however, that in a majority of the cases no disease has been found in this region has made Charcot's assumption of a system with such specific functions untenable. Soon after, Gowers, drawing attention to the constant absence of such involuntary movements in completely paralysed limbs, attributed their occurrence to "damage to the gray matter of the brain, to local perverted nutrition of the nerve cells, in

consequence of which they overact, either spontaneously or on the stimulus of a volitional impulse, which is by their over-action perverted or irregularly distributed;" and he assumes that this gray matter must be in connection with the volitional centres. From the result of the anatomical examination of one of his cases he further asserts that this gray matter is that of the optic thalamus. In a later publication Gowers suggests that the symptoms may be due in many cases rather to the quality of the lesion than to its site. Monakow closely follows Gowers in regarding "irritative disease of the optic thalamus, in the form of multiple small foci," as the direct cause, assuming that from these abnormal impulses ascend to the motor cortex. Since then this localisation of the lesion has been widely accepted, and it has in many cases been verified by autopsy. In every case the disease has been limited to the posterior end of the thalamus, with the doubtful exception of one recorded by Lauenstein, in which hemiathetosis resulted from an affection of the anterior end. That in the majority of the cases the lesion has been unprogressive, of long duration, and often only the remains of vascular disease, as well as the permanency of the symptoms, are, however, strong arguments against the view of the pathogenesis of the symptom accepted by these authors. Benedict had still earlier assumed that the essential condition was an affection of some accessory motor organ which has a regulating influence on the primary motor system, and pointed out its association with disease of the mid-brain.

The accumulation of published cases with a number of autopsies showing very various sites of the disease, has caused the later authors to take a more comprehensive view of the subject. Muratow, for instance, regards the symptom as due to a disturbance of the equilibrium between the inhibitory action of the cerebellum and the tonic influence of the thalamus, on the spinal cord. Anton, in his earlier work, assumed a disturbance of the equilibrium between the centres for automatic and those for voluntary movement. Theoretically this might occur anywhere that the connections of the centres are relaid in gray matter, but it most

frequently results from disease of the basal ganglia, and especially of the lenticular nucleus. It would thus be due to loss of the inhibition which the basal ganglia normally exert on the cortex. In a later publication he assumed the direct cause to be the destruction of a centrifugal tract of cortical origin, which passes to the cord through the cerebellum.

Bonhoeffer, on the other hand, regards the condition as the result of the interruption of a cerebro-petal tract which carries co-ordinating impulses to the cortex, probably from the cerebellum, and asserts that the relative integrity of the cortex and pyramidal system are necessary for its appearance. Only part of these co-ordinating impulses reach the cortex, the rest becomes disseminated in the basal and mid-brain ganglia, and from there passes to the cord through centrifugal tracts. In this way he explains the existence of automatic movements.

Nothnagel and others have expressed the opinion that, though it may result from disease of fibres in relation to the optic thalamus, the symptom has no localising value, and may be due to the central irradiative of volitional impulses.

I have been able to collect sixty cases, with autopsies, from the literature which during life presented the symptoms of spontaneous involuntary movements. Only those were taken for statistics of which there was a definite description of the nature of the involuntary movements, though in many cases, for the reasons above mentioned, it can scarcely be hoped that the description was either true or accurate; yet they serve at least to give an indication of the site of the disease associated with each variety. On the other hand, cases have not been included in which the lesion was either multiple or too extensive to warrant conclusions.

For the purpose of tabulation the involuntary movements have been divided into three classes, namely, athetosis, chorea, and tremor. The published records of fifteen cases of the first form were investigated. In four cases the lesion was accurately limited to the optic thalamus, in six it was chiefly situated in the basal ganglia, frequently involving the thalamus too; in two cases the internal capsule was the chief site of the disease; in one case the corona radiate, and in another the mid-brain was involved.

Movements described as hemi-chorea resulted in two cases from affection of the optic thalamus; in five cases of the other basal ganglia, but especially of the nucleus lenticularis; in ten cases from mid-brain lesions; in two from tumour of the pons and bulb, and in one from disease of the cerebellum.

Twenty-five cases were found in which, from the description, the involuntary movements seem to fall within the definition of tremor above given. In three of these cases the lesions were situated in the thalamus and basal ganglia; in twenty cases in the mid-brain; in two cases in the cerebellum; and in one in anterior part of the pons, extending dorsalwards, to compress or directly involve the cerebellum.

No trustworthy case has been published in which the lesion was limited to the cortex. In that of Demange almost one-half of the hemisphere was involved in the softening, and the deep portions of the brain were not carefully enough examined to exclude disease in them.

As regards the variety of the symptom found associated with disease of the different regions, we see that in twenty-one cases the disease was limited to the optic thalamus, basal ganglia, and internal capsule; and in eleven of these cases athetosis resulted; in seven choreiform movements; and in three tremor. In thirty-one cases the disease was in the mid-brain, and in these the relative frequency of the various forms are reversed, athetosis only appearing once, choreiform movements ten times, and tremor twenty times. In three cases the cerebellum was involved, in the one producing choreic symptoms, and tremor in the other two cases. In three cases, too, the pons varolii and medulla were affected, producing in two of the cases choreiform, and in one tremor-like movements. And, finally, in one case, in which the movements took the form of athetosis, there was some destruction of the corona radiata.

Although these figures may not accurately represent the relative frequency of the different varieties of involuntary movements, or of the sites of the lesions associated with them, it may safely be assumed that athetosis almost always results from disease of the basal ganglia, but especially of

the optic thalamus, that choreiform movements occur with about equal frequency in lesions of the basal ganglia and of the mid-brain, while in the large majority of the cases of tremor the lesion involves the mid-brain.

Finally, it remains necessary to point out that these facts are entirely consistent with the conclusions arrived at from the study of the cases above recorded, viz., that tremor, associated with focal cerebral disease, may depend on a negative lesion of the mid-brain, or rather of the cerebello-rubral system. It must be remembered that the nucleus ruber is phylogenetically, as well as developmentally, a portion of the thalamencephalon, and though it is generally regarded as a mid-brain structure, it projects so far into the 'tween-brain that direct injury of it must frequently result from disease which is described as limited to the thalamus.

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THE PATHOLOGY OF INFANTILE PARALYSIS (ACUTE ANTERIOR POLIOMYELITIS).

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THE pathology of acute anterior poliomyelitis is a subject around which very considerable discussion has from time to time taken place. Briefly stated the views which are and have been held are as follows :—

(1) That the condition is due to a direct affection of the anterior horn cells.

(2) That the condition is due to an acute inflammation in the region of the anterior horns.

(3) That the condition is due to a vascular lesion which may be either thrombotic or embolic.

There is, I believe, no doubt that cases occur which belong to the first group, but they do not clinically conform to the usual type of acute infantile paralysis, but have a more gradual onset, a wider distribution, and the final condition is one of widely distributed weakness, and it may be atrophy of muscles, and not the localised weakness and atrophy seen in the more usual form of infantile palsy. It is not my intention at the present time to discuss this point.

The view that is most commonly held of the pathology of acute anterior poliomyelitis is that the condition is due to an acute inflammation which may be of bacterial origin, or may be due to some form of poison of unknown origin having an especial selective action on the anterior horn.

The third view that the condition is directly due to thrombosis or embolism is that held by but few observers, and it is with the object of showing that this is probably the most correct view that the three following cases are now recorded.

Of the three cases described below, the first died on the thirteenth day after the onset of the disease, the second died three months after the onset, and the third two years after the onset.

Case 1.—F. L. aged 14 months, was in perfect health till nine days before he was first seen; he could use his arms well and could walk with a little assistance. One morning his mother noticed that the child was feverish, and on the evening of the same day she noticed that his back was weak, and that his head fell about anyhow; during the next few days his weakness increased, so that in three days after the onset he was perfectly helpless in all his limbs, and his voice became very feeble. There was no vomiting or diarrhœa, and the child had had no preceding illness.

On admission to the hospital the child was completely paralysed in all four extremities; there was complete paralysis of the muscles of the back and neck and paralysis of the intercostal muscles. The knee-jerks were absent, but sensation was perfectly normal.

The muscles of the arms showed the reaction of degeneration, but a complete examination was not made owing to the feeble condition of the child. The temperature varied from 99° to 100° F. in the evening, falling to normal in the morning. Three days after admission the child suddenly died while being fed.

Pathological examination.—To the naked eye the cord appeared perfectly normal and all the organs of the body were healthy. The cord was placed in Muller's fluid, and, after hardening for six months, was passed through the usual media, imbedded and cut in colloidin. Sections were stained by the Weigert-Pal method and with hæmatoxylin, eosin and carmine.

On examination of the specimens stained by the Weigert-Pal method nothing obviously abnormal could be detected, the medullated fibres of the white matter were well stained, and the finer fibres of the gray matter in the posterior portion of the cord were normal. In the anterior horns, however, the fine medullated fibres were more broken up and separated than normal. Sections taken from the lumbar region which had been stained with eosin and hæmatoxylin showed very considerable inflammatory change in the gray matter of the anterior horns. The vessels were widely dilated and surrounded by numerous small round cells which lay in the perivascular lymphatic space. Many of the vessels were thrombosed, and small extravasations of blood could be seen at various points

(plate I., fig. 1). The dilatation of vessels was practically limited to the ventral portion of the cord, and was far more marked in the gray matter of the anterior horn than in the white matter, but the vessels passing through the white matter were undoubtedly affected. A few nerve cells could be seen situated as a rule close to the junction of the gray and white matter. The anterior median artery and its larger branches could be seen to be thrombosed.

In the thoracic region of the cord the inflammatory process was still present, but was not so intense as in the lumbar region; the cells of Clarke's column were normal.

In the cervical region a similar process was present, but to a lesser degree, and several normal cells could be seen in the anterior horns.

Even in the medulla there was perivascular exudation, although there was very little change in the nervous structures.

The case was under the care of the late Dr. Sturges, at the Children's Hospital, in 1893. No bacteriological examination was made, nor was the cord examined by Marchi's method.

Case 2.—The second case was that of a female child, aged 6 months, who was admitted to the Hospital for Sick Children, under the care of Dr. Garrod, on October 4, 1900, and to him I am indebted for permission to publish this case.

The history of the case was that the child eight weeks previous to admission awoke screaming, and the mother found that the child was powerless in all four extremities, on the following day it cried when moved, and on the next day lost its voice, and it had not coughed or sneezed since.

After fourteen days it recovered the use of its arms, but no return of power took place in the legs. It was the first child, and up to the onset of the illness was perfectly well and had been breast fed.

On admission to the hospital the child was well nourished, it could hold its head up, but was unable to sit up; there was an internal strabismus. The chest was well developed, but the respirations were almost entirely diaphragmatic. The arms were moved quite naturally, but the legs were absolutely flaccid and powerless, the knee-jerks were absent, and the plantar gave a flexor response. There was some difficulty in swallowing, but no regurgitation of fluid through the nose and the palate moved well. The child developed broncho-pneumonia, and died some five weeks after admission.

At the autopsy a considerable amount of broncho-pneumonia was present. The brain and spinal cord appeared normal on their external surfaces. Cultures were taken from the spinal fluid and from the gray matter of the cord, and the following was the report furnished by Dr. Thursfield.

(1) Cultures from the fluid grew:—

(*A*) a short bacillus taking the stain with some difficulty and growing in great profusion. (I believe this to be proteus vulgaris.)

(*B*) A fat coccus growing very scantily, strongly resembling cocci from infected wounds.

(*C*) A large number of ordinary staphylococci.

(2) Cultures from the anterior horns grew:—

(*a*) A short bacillus taking the stain badly, but apparently not identical with 1 *A*.

(*b*) The same fat coccus above described.

There were no staphylococci, and both the above were probably ordinary contamination bacteria.

After the cord had been hardened in formalin for three days, sections were made in a transverse direction. The medulla, cervical and thoracic region appeared normal. At the level of the first lumbar segment the anterior horn appeared redder than normal, and in all the lumbar and upper sacral segments both anterior horns were red and softened and had a gelatinous appearance.

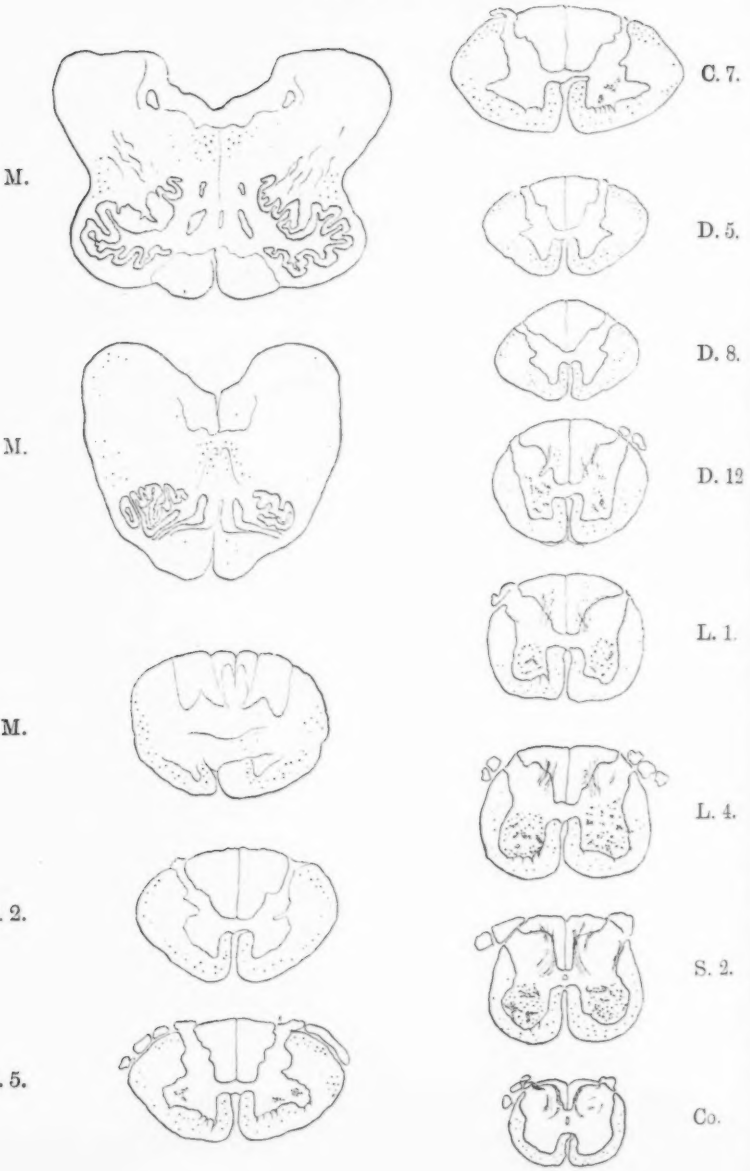
This condition was strictly confined to the anterior horns, and did not involve the white matter of the cord. After section of the cord, this gelatinous material shrank away from the level of the section, so that a depression appeared in the situation of the anterior horns.

Microscopical examination.—Sections of the cord were stained by the Marchi, Weigert-Pal, Nissl and van Giesson methods.

On examining sections stained by the Marchi method, it was found that an area of softening was present in the region of the anterior horn extending through the lumbar region from the twelfth dorsal to the upper sacral segments on both sides. In this area of softening were seen large numbers of fat granules; some of these were especially numerous in the perivascular lymphatics, and marked out the course of a vessel, while others were distributed throughout the area of softening (plate II., figs. 1 and 2).

At the level of the fifth and seventh cervical segments, small areas of softening similar to those in the lumbar region could be seen occupying a situation in the anterior horn (plate III., figs. C. 5 and C. 7).

PLATE III.



Scattered throughout the antero-lateral tracts were numerous degenerate fibres; these could not be said to be confined to any one tract, although in the upper thoracic and cervical region they tended to limit themselves to the direct cerebellar tract and anterior portion of the white matter, leaving the crossed pyramidal tracts less affected (plate III., figs. C. 2, 5, 7, D. 5). This degeneration could be traced up to the direct cerebellar tract, and to the region of the posterior longitudinal bundle in the medulla. A few degenerate fibres could be seen in the posterior columns in the lumbar region, but they did not form any definite tract.

It may here be noted that an essential chemical difference in the constitution of the fat which occurred in the gray matter and that which occurred in the white must exist, for the fat of the gray matter, which was intensely stained by osmic acid, rapidly lost its blackness when mounted in xylol canada balsam, whereas the stained fat in the white matter remained unaltered.

In section stained by the Weigert-Pal method, the most striking naked-eye feature was the difference in staining between the posterior and antero-lateral tracts. The former were darkly and well stained, while the latter were pale. The same points, however, could be observed with regard to the crossed pyramidal tracts, as was noted by the Marchi method, viz., that they were less affected than other parts of the antero-lateral tract (plate IV., fig. 1). The fibres of the direct cerebellar tract on the outer side of the cord were better stained than those nearer the crossed pyramidal tract, it seems therefore probable that the inner group of fibres arose from the lower segments of the cord (plate IV., fig. 1).

With regard to the condition of the gray matter, the most striking feature was the absence of nerve fibres and nerve cells in the anterior horns in the lumbar region of the cord (plate IV., fig. 2).

By the Nissl method the paucity of all cells in the anterior horns of the lumbar region was the most striking feature; in the same region a few cells were, however, present, and appeared normal in structure. In the lower thoracic region the cells of Clarke's column were affected on the one side, while they were apparently normal on the other. The paucity of cells in the thoracic and cervical region was striking, especially when the relatively good movement that the child had in the arms was taken into consideration.

By the van Giesson method the anterior horns of the lumbar region were seen to be occupied by a tissue composed of fine filaments with comparatively few nuclei, resembling very closely the

tissue found in a glioma. There were numerous newly-formed vessels in this area, but there were no signs of acute inflammation.

The walls of the anterior median artery appeared rather thicker than normal, but otherwise the vessels appeared natural. The white matter and the posterior horns of the cord appeared normal.

The muscles of the legs showed most extensive atrophy, practically no normal muscle fibres existing, the biceps muscle of the arm contained both atrophied and normal muscle fibres (plate V., fig. 2). The muscle spindles were well preserved, and the intrafusal fibres were normal, thus corresponding to the condition which has been shown to be present in the muscles of cases of infantile paralysis (BRAIN, vol. xx). The nerves within the muscle spindles were normal.

The nerve trunks (sciatic and anterior crural), considering the extreme atrophy of the muscles, contained a large number of normal nerve fibres (plate V., fig. 1); but it will be noticed that the majority of these fibres are of large size, and almost certainly sensory and connected with the posterior roots.

Case 3.—The third case is that of a boy, aged 4 years, who was admitted to the hospital for sick children, under the care of Dr. Barlow, suffering from tuberculosis. He died of tuberculous meningitis.

Two years before admission to the hospital he had an attack of infantile paralysis, losing the use of both legs and the left arm. The left arm and the left leg rapidly recovered, but the weakness of the right leg persisted, and there was marked wasting of the right thigh and leg. The knee-jerk on the right side was obtainable, while that on the left side was brisk.

The spinal cord at the time of the *post mortem* appeared normal when, however, after hardening, the roots of the cauda equina were carefully separated it was seen that some of those on the right side had a gray appearance, and were thinner than the corresponding roots of the left side; this was most marked in the first sacral root.

The cord was stained by the Weigert-Pal and by the Nissl method.

On examining sections stained by the Weigert-Pal method at the level of the third lumbar segment, it was noticeable that the anterior horn on the right side was smaller than on the left, and that the whole of the white matter of the antero-lateral column stained less intensely than the white matter of the posterior columns (plate IV., fig. 3).

Under the microscope the difference between the number of medullated fibres in the gray matter of the anterior horns was the most striking feature, and in one part of the horn practically no medullated fibres existed. The difference in the emerging fibres of the two sides to form the anterior roots was also striking, for on the one side they were well stained, while on the other they were pale and atrophied. With regard to the cells of the anterior horn, the greatest diminution appeared at the level of the third lumbar segment, but even in this region one or two groups of well-formed cells were present. The roots on the affected side were seen to contain far fewer normal fibres than the unaffected side.

Discussion.

The three cases above recorded illustrate the changes which are found in acute anterior poliomyelitis at various stages of the disease (so far as the bacterial cause of the disease is concerned nothing has been learnt).

In the cord of the child who died fourteen days after the onset of the disease, the acutest inflammation was present in the gray matter of the anterior horns, with a large amount of small round cell exudation, hæmorrhages and thrombosis of vessels. In the second case an area of necrotic tissue limited to the anterior horns in the lumbar and sacral regions. In the third case a diminution in the size of the anterior horn of the affected side due to cicatricial contraction.

The question at once arises, what is the cause of this affection of the anterior horn which in the first place gives rise to the acutest inflammation, then to necrosis, and finally to cicatrisation?

Is the condition due to a primary inflammation, followed by a thrombosis of vessels, or is it primarily due to a thrombosis of vessels followed by inflammatory changes and hæmorrhage, for certainly so far as the present series of cases is concerned, the view that this condition is due to a direct affection of the cells of the anterior horns may be dismissed?

Both theories have had their advocates, and quite recently Head and Campbell have strongly expressed the opinion

that the thrombosis is secondary to an acute infection probably of bacterial origin; their argument is as follows, and may well be given in their own words:—"If by 'vascular' is meant that the disease is directly secondary to occlusion or interference with a vessel we deny its correctness, if, on the other hand, it is meant that the vessels play an important part in the general inflammatory process it is a *platitude*. Many observers have occluded the vessels of the spinal cord for varying periods, and examined the changes so produced in the cells. Such occlusion of the arteries produces marked chromolytic change in the cells of the spinal cord, but is not followed by inflammatory change or hæmorrhages. Leonard Hill ligatured the cerebral arteries in monkeys, and the brains of these animals were examined by Mott at varying periods after the operation. Here, again, extreme chromatolysis of the cortical cells was found, but no inflammatory change or hæmorrhages."

Such arguments sound almost conclusive, but it must be remembered that obliteration of a large vessel is by no means necessarily comparable to the condition which is produced when thrombosis occurs in smaller vessels. Far more to the point are the experiments of Prevost and Cotard (although performed many years ago) with regard to the changes which take place in an infarcted area. By the means of fine tobacco seeds they succeeded in producing infarcts in various organs, and they proved by their experiments that congestion, hæmorrhages and exudation of cells were the early results of obliteration of small vessels. They enter fully into the mechanical explanation of this congestion, but it is unnecessary here to deal with the somewhat prolonged discussion on that point, but the fact that exactly similar changes such as are found in early cases of infantile paralysis, viz., hæmorrhages and small cell exudation, may be produced by obliteration of small vessels at once negatives Head's and Campbell's assertion that "inflammatory changes" are not the result of thrombosis.

Having thus established the possibility of such a condition as is here present being due to primary occlusion of vessels, it remains to be seen what evidence there is that the

condition may be due to the obliteration of any one vessel or set of vessels. The gray matter of the anterior horns receives its chief blood supply from branches of the anterior median artery. Branches from this artery come off at the lowest part of the anterior median fissure, and entering the gray matter of the anterior horn supply the whole of the gray matter on the ventricle side of, and including the column of Clarke, but not the posterior horns nor the white matter of the cord. Now, in the spinal cords from cases of infantile paralysis the line of demarcation between the affected and unaffected portion is sharply defined not only in the acute cases, but also in the cases of longer standing. It cannot be denied, however, that the vessels in the ventral portion of the spinal cord outside the gray matter are engorged, but there is no softening such as is present in the gray matter. The line of demarcation in cases of infarct in which the acute stage has passed is always sharp and well defined, and so is the area of softening in the anterior horn of infantile paralysis, and, when one remembers how closely the area of softening corresponds to the distribution of the branch of the anterior median artery, it is but reasonable to suggest the great probability that such a condition is due to an occlusion of a vessel or vessels.

Again, if the condition which is present in the cord of a child who has suffered from infantile paralysis be compared with that due to the thrombosis of small vessels in the brain, the conditions are strikingly similar.

Further, the occurrence of the disease most frequently in the lumbar region seems to be another point greatly in favour of the view that the condition is primarily vascular, for it is known that the gray matter of the anterior horn of the lumbar region is situated at a point most peripheral from its blood supply, which is derived from the vertebral artery, the blood has therefore to travel the whole length of the spinal arteries, and, further, it has been shown by Moxon that the reinforcing arteries of the roots do not readily assist in the supply of this part of the cord, for they cannot be injected through the femoral artery.

From a clinical standpoint it might be argued that the

occurrence of the disease during the hot months of the year, and in epidemic form in several members of a family, point to the direct bacterial origin of the disease. The liability to thrombosis after the acute specific infection is well known, and it is not unreasonable to suggest that the direct cause of the disease is a thrombosis of a vessel or vessels, and that this thrombosis is due to some morbid condition of the blood and vessel walls, such morbid condition being produced by various and totally different forms of infection.

In conclusion, the view taken by the author with regard to the pathology of acute anterior poliomyelitis may then be briefly summarised as follows :—

(1) That the condition is due to a primary thrombosis of a branch or branches of the anterior spinal artery supplying the gray matter of the anterior horn.

(2) That such thrombosis may be produced by many and various forms of infection, and the disease is not due to a special specific infection.

(3) That the condition is more likely to occur in the lumbar region owing to the blood supply of this portion of the cord being at a point most distal from the heart, and the long course of the reinforcing arteries.

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Description of Plates.

Plate I.

Fig. 1.—Transverse section of the lumbar region of the spinal cord of a child, who died thirteen days after the onset of acute anterior poliomyelitis, stained by Weigert-Pal method and counterstained with carmine.

The vessels in the gray matter are thrombosed and surrounded by perivascular exudation; there are scattered hæmorrhages throughout the gray matter and exudation of small cells. The congestion is almost limited to the ventral portion of the cord.

PLATE I.

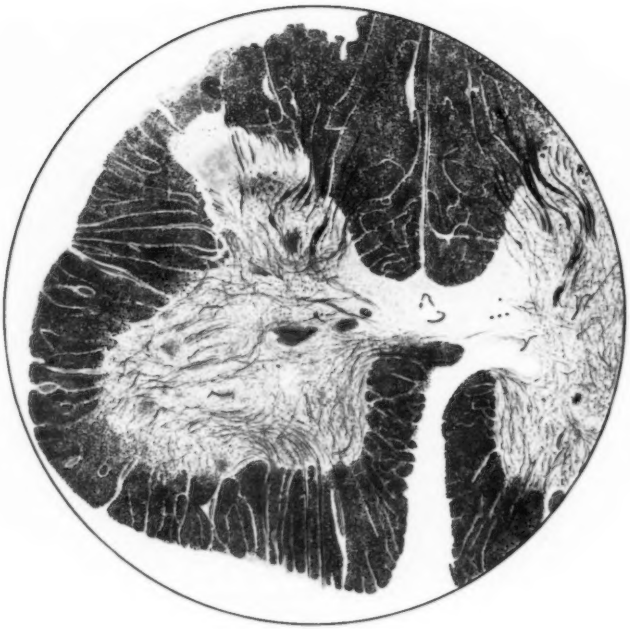

PLATE II.

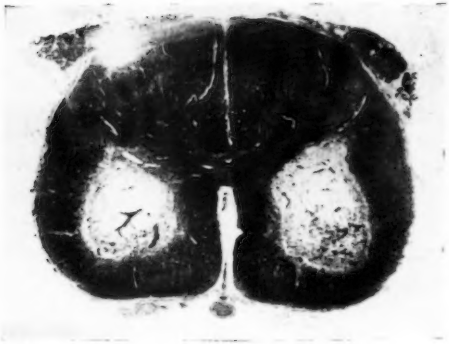

FIG. 1.

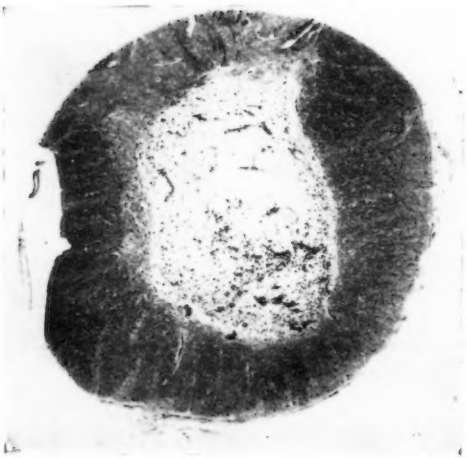

FIG. 2.

PLATE IV.

PLATE IV.

FIG. 1.

FIG. 2.

FIG. 3.

PLATE V.

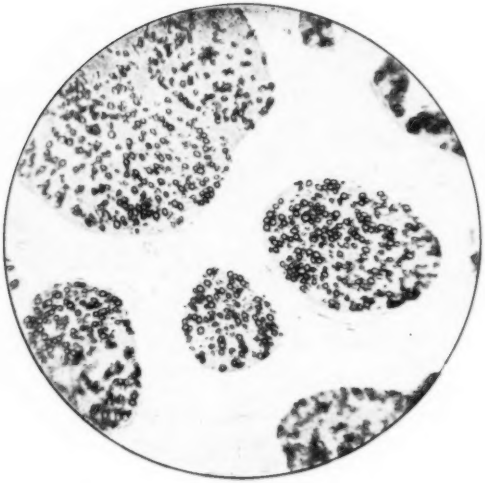

FIG. 1.

FIG. 2.

Plate II.

Fig. 1.—Transverse section of the lumbar region of the spinal cord of a child three months after the onset of acute anterior poliomyelitis. Section stained by the Marchi method. The area of softening is limited to the gray matter of the anterior horns. On the left side the fat lying in the perivascular space marks out the position of a vessel in the centre of the gray matter.

Fig. 2.—The right horn under higher magnification, showing the black-stained fat granules scattered throughout the softened area of the anterior horn.

Plate III.

Series of sections of the spinal cord of a child, aged 6 months, three months after the onset of acute anterior poliomyelitis showing degeneration in the antero-lateral tracts and in the direct cerebellar tract. The degeneration can be traced up into the cerebellar peduncles and the posterior longitudinal bundles. Small areas of softening are seen in the gray matter of the cervical region (figs. C. 5 and C. 7), and in the gray matter of the twelfth dorsal, the lumbar and sacral region; there is extensive destruction of the gray matter on both sides (figs. D. 12, L. 1 and 4, S. 2). In the coccygeal region of the cord the gray matter is normal.

Plate IV.

Fig. 1.—Transverse section of the cervical region of the spinal cord of same child above described stained by the Weigert-Pal method. The section shows degeneration of the inner fibres of the direct cerebellar tracts, and also considerable degeneration in the ascending antero-lateral tracts.

Fig. 2.—Transverse section of the lumbar region of the same case showing destruction of the anterior horns. There is almost complete absence of all fine medullated fibres in this region. In the antero-lateral tracts there is a scattered degeneration, as shown by the general paleness of these tracts as compared with the posterior columns.

Note the absence of medullated fibres in the anterior horns.

Fig. 3.—Transverse section of the lumbar region of the spinal cord of a child two years after the onset of acute anterior poliomyelitis, showing diminution in the size of the anterior horn on the right side, diminution in the number of fine medullated fibres in the gray matter, and diminution in size of the antero-lateral tracts on the right side.

Note the diminution in size of the R. anterior horn.

Plate V.

Fig. 1.—Transverse section of the right sciatic nerve of Case 2 (three months' standing) showing numerous normal medullated fibres of large size, whilst most of the smaller fibres have atrophied. The large medullated fibres are probably those in connection with sensory terminations.

Fig. 2.—Transverse section of biceps muscle of the arm of the same child showing some normal fibres and many atrophied fibres. The muscles of the leg practically contained no normal fibres.

ON SO-CALLED FACIAL HEMIHYPERTROPHY.

BY H. MACKAY, M.D., DEVIZES.

THE extreme rarity of this condition is a sufficient reason for recording a fresh case, and for recapitulating what is known of it.

Described first by Beck in 1836 (1) it was nearly thirty years before a second case was reported by Friedreich (2). The Heidelberg professor described a third case observed by Heumann (3), and to these, Passauer in 1866 (4) added a fourth.

In 1869 Trelat and Monod (5) published a monograph on the condition of unilateral hypertrophy, partial or complete. The authors collected twelve cases of this condition, some of which, viz., those of Devouges (6), Ollier (7), and Monod (8), have been referred to since as instances of facial hemihypertrophy. I have not included them in the present series of cases, however, because the original observers state regarding each case that the facial asymmetry was insignificant, or that it eluded measurement.

The next contribution of importance was that of Fischer, on "Giant Growth," in 1879 (9). Fischer reported a fresh case of facial hemihypertrophy under his own care, and endeavoured to classify the various cases of hypertrophy that had already been reported.

He distinguished between "true" and "false" hypertrophy, limiting the former term to those instances in which all the tissues of a part were equally enlarged, and the part remained functionally useful, and assigning the latter to those in which the enlargement was due to, and was restricted to, over development of one tissue only.

The division was unsatisfactory and is now obsolete. It left unclassified the cases in which more than one tissue,

e.g., fat, sebaceous glands, and connective tissue have undergone hyperplasia, but in which all the tissues of the part, *e.g.*, the bones, have not participated.

While undoubtedly the conditions of lymphangioma and telangiectasis which Fischer appears to have had in view in framing his distinction, ought to be excluded from the list of hypertrophies, yet the latter term has, by the common consent of pathologists, been applied to those cases where hypertrophy or hyperplasia of one tissue, such as connective tissue or muscle, has taken place without exhibiting the intrinsic characters of tumour formation.[1]

Passing over the contributions of Ziehl (10), Schieck (11), and Finlayson (12), each of whom described a fresh case, Lewin (13) in 1884 published an elaborate paper on what he considered to be the correlated conditions of facial hemiatrophy, facial and bodily hemihypertrophy, and cutaneous pigmentation. He gave a list of published cases in each class, including a case of facial hypertrophy of his own. He included in the latter condition, however, two cases published by Stilling (14), to which as cases of facial hemihypertrophy exception may reasonably be taken. Both were cases of swelling of the soft parts of the cheek, in one instance as large as a child's head, in the other as large as a man's fist, which appeared subsequently to injuries in this region. Both were accompanied by extreme dilatation of the blood-vessels of the part; in one case telangiectatic excrescences the size of raspberries being present, while in the other a semi-erectile condition existed, the swelling becoming plainly larger and more distended when the patient bent over.

Inasmuch as local ectases and vascular dilatations are of frequent occurrence in the records of undoubted cases of

[1] Whether osseous hypertrophy—hyperostosis, pure and simple—of a part such as the face or skull should be placed in a category apart from the condition of mixed overgrowth of bones and soft parts, which, in the majority of instances characterises facial hemihypertrophy, appears to be at present undecided.

Mr. Hutchinson has described (26) as "Unilateral Hypertrophy of the Skull" a case, to be referred to later, which would probably be classified during life as unilateral facial (and cranial) hypertrophy.

Brissaud also (62) has recently described as "hemicraniosis" two cases in which the condition is apparently identical with that described by Mr. Hutchinson. To these cases also reference will be made later.

facial hypertrophy, and it is difficult to decide from Stilling's account how much of the swelling in each case was due to angiomatous conditions and how much to hyperplasia of tissues other than vascular, I have not felt justified in altogether omitting these cases, but have placed them, as doubtful instances, in a division apart.

It is, however, to the Salpetrière school that we owe the most important recent studies of the subject. Sabrazés and Cabannes (15) in 1898 described a fresh case with a bibliography. Their list of published observations, however, requires revision, as they have included as instances of facial hypertrophy, cases (*e.g.*, *Obs.* xiii. in their series) in which the face was not affected. These authors distinguish between the congenital and the acquired cases, and assign to each a different pathogeny. To this point reference will be made later.

Still later, the teachings of Brissaud on the influence of metamerism in nervous disease, and of Meige on chronic dystrophy, have drawn the attention of many of their pupils to the subject of hypertrophy of limbs, and other portions of the body. Unilateral hypertrophy of the face has also come within the purview of these studies.

The question whether facial hypertrophy, in any form, may be considered as a dystrophy allied in its nature to trophœdema or not is yet an open one. Meige himself (16) adopts towards the suggestion an attitude of caution.

As regards several instances of facial hemihypertrophy, however, *e.g.*, those of Beck, Berger, and Ziehl, in which the facial enlargement has concerned the soft parts only, and has exhibited the characters of a swelling, not pitting on pressure, colourless, and painless, it would appear to be difficult to separate the condition clinically from that described as "chronic trophœdema" of Meige. It is for this reason that I have included in the list of cases given below, the examples described by Rapin (17), Hertoghe (18), and Thomas (19).

English and American observations of the disease have been scanty.

Barwell (20) described a case in 1875, and again in 1881.

Heath (21) figured a case in "Injuries and Diseases of the Jaws." Sir Geo. Humphrey (22) described and figured a doubtful case, in which the gums were chiefly concerned, in 1886. In each of these cases it was the surgical rather than the neurological interest of the case that appealed to the observer.

Dr. Montgomery, of San Francisco (23), in describing a case, published a brief but excellent résumé of the subject in 1893.

Mr. Hutchinson and Dr. Alexis Thompson (26) have each reported cases of what the former describes as "Unilateral Hypertrophy of the Skull," and have admirably described, from skulls in their possession the osteo-pathic changes which occur. As regards the facial condition of these patients during life, the details are not sufficiently full to allow of their being tabulated with the other cases here presented. While it is in doubt, however, whether and to what extent the soft parts were involved, I think there need be no hesitation in including them as cases of facial (and cranial) hemihypertrophy.

Brissaud and Lereboullet (62), in the cases already alluded to above, describe a condition of hyperostosis of one half of the face and skull in the region of the trigeminal nerve, for which they propose the distinctive title of "hemicraniosis."

In the first case epileptic attacks commenced at the age of 20 in a patient in whom, from the age of two months, there had been noticed asymmetry of the face, with bossing of the left frontal bone. Headache, but no vomiting, was present, and the fundus was normal.

In the second, the enlargement of the face and skull had also existed from childhood. The right half of the face was hypertrophied, and there was a well-marked painless boss in the right frontal region. Latterly, there ensued vomiting, headache, strabismus, double choked disc, exophthalmos, and ultimately complete blindness, leading up to exitus lethalis.

The autopsy showed the presence of numerous small angiolithic tumours on the inner surface of the dura on the

right side, and multiple exostoses, the size of nuts, on the inner aspect of the cranium on the same side, which corresponded to correlated depressions in the cerebral substance.

The authors claim for these cases a certain relationship to facial hemiatrophy, inasmuch as in each condition there is present a unilateral trophic affection in the region of the trigeminal.

The condition thus depicted appears to be identical with that described by Hutchinson and Alexis Thompson as unilateral hypertrophy of the skull, and by other observers as facial hemihypertrophy, but, in deference to the distinctive nomenclature adopted for it by so distinguished an authority as Brissaud, I have excluded these observations from the subjoined list of cases of facial hypertrophy.

In the cases here given, the original records have been consulted in all instances, with the exception of Cases 1, 14, and 22.

In addition to the observations of Ollier, and Monod, already referred to, I have omitted several others included by former writers, on account of the poverty of detail in the available records. Such are those of Steffen (27), Zhukovsky (28), and Stembo (29), quoted by Messrs. Sabrazés and Cabannes, and that of Logan given in the *Virchow-Hirsch Jahresbericht* for 1868.

Of the associated, but commoner, condition of unilateral hypertrophy of the body, the literature is too voluminous to attempt to refer to it here.

Case 1.—Beck. *Medicinische Annalen von Puchelt, Chelius und Naegele*, 1836, Bd. II., No. 1, p. 89 (quoted by Ziehl—*Virchow's Archives*, Bd. xci.).

A girl of 3 years presented a hypertrophic fulness of the right cheek, which had been present since birth, and increased with the growth of the child. The soft parts alone were affected.

Case 2.—Friedreich, 1863 (quoted by Ziehl), *Virchow's Archiv.*, Bd. xxviii., p. 474.

A girl of 16 showed soon after birth enlargement of the right side of the face, chiefly marked in the infraorbital portion. The forehead and eyes were symmetrical. The external ear was

enlarged in all directions. The hypertrophied side showed circumscribed patches of pigmentation, and an enormous development of abnormal hairs existed on the ear, cheek, temple, and along the jaws. The hairy scalp and the hands showed no abnormal development in the hairs. The irides showed similar coloration. An exaggerated sebaceous secretion covered the neighbourhood of the ear and mastoid with a greasy layer.

On the right side the alveolar processes of the upper and lower jaw were double the thickness of the opposite side; the teeth also were larger, longer, and thicker than those on the left. Toothache was frequent.

The right tonsil and right half of the tongue were much enlarged, and the saliva was more abundant on this side. On the hypertrophied half of the tongue sensibility to taste and touch were less developed. The right cheek was of a deeper colour than the left, and experienced a subjective sensation of warmth. The child suffered from otorrhœa on the right side.

An autopsy was obtained, but nothing throwing any light on the condition was found. The nerve trunks at the base of the brain were unaltered (macroscopically). The petrous portion on the right side was hypertrophied, and showed exostoses projecting from its surface which had indented and compressed the opposing surface of the brain.

Friedreich also communicated the following case:—

Case 3.—Heumann (*loc. cit.*).

A girl, five years old, had shown since birth enlargement of the left side of the face, which involved the cheek, the two jaws, the teeth and the tongue. The skin of the ear was thickened, and the hairs more developed. There had been a fœtid otorrhœa from the left ear since birth, but the hearing was not impaired. There was a constant flow of saliva from the left side of the mouth.

The child died from meningitis following caries of the petrous bone. No autopsy.

Case 4.—Passauer, 1866, *Virch. Archiv.*, xxxvii., p. 410.

A boy of 11 showed congenital hyperplasia of the left side of the face. During pregnancy the mother was crushed by a wagon against a wall, and suffered severe abdominal pain for some time.

The enlargement involved the cheek, upper and lower lips, and the chin, and was limited by the median line of the face. The

alveolar borders of the upper and lower jaws were much enlarged on the left side, as also was the left half of the tongue and palate, and the teeth. On the hypertrophied portion of the face there was no play of expression.

Case 5.—Berger. "Zur Aetiologie und Pathologie der sogenannten Muskelhypertrophie." *Deutsche Archiv. für Klin. Medicin*, 1872, p. 393.

In a woman of 58, Berger noticed hypertrophy of the face supervene in the course of severe and obstinate trigeminal neuralgia. The hypertrophy concerned the soft parts only, and especially the subcutaneous connective tissue.

Case 6.—Fischer. "Der Riesenwuchs." *Deutsche Zeitschrift für Chirurgie*, Bd. xii., 1879.

In a boy of 7 months the left side of the face had been hypertrophied since birth. The enlargement and thickening affected all the tissues. The skin showed normal structure, and the bones were smooth. Of the latter those chiefly affected were the upper jaw and the frontal bone. The circumference of the head in the frontal plane was 56 cm., of which the left half measured 31, and the right 25 cm. The tongue was normal, and the hairs of the scalp, eyebrows, and eyelashes were equally developed on both sides. There was no difference in the eyes, or in the lachrymal secretion of the two sides. No discolouration was present. Motility, sensibility and temperature, were normal.

Case 7.—Barwell. *Transactions of Clinical Society*, vol. xxxii., 1881.

A boy of 13 showed enormous hypertrophy of the right side of the face. It affected the head and face. (It appears to be chiefly infraorbital in the illustration. H.M.)

The texture was soft and yielding.

Near the ear was a patch of dark horny ichthyosis (true hypertrophy of the cuticle), which was increasing in size.

The upper and lower maxillæ were massive and thick, and the teeth were hypertrophied also. The tongue was enlarged on the affected side.

Mr. Barwell suggests a perverted action of the sympathetic as a probable cause. The common carotid was tied, and the patient died from secondary hæmorrhage.

As an appendix to the above may be quoted a previous observation of Mr. Barwell's recorded in the *Medical Times and*

Gazette, vol. i., 1875, which, though not unilateral, possesses considerable interest. The patient was a lad of 19, who showed hypertrophy of both sides of the face. It affected the soft parts only, the bones being of natural size and shape. It was stated to have appeared in a single night.

Mr. Barwell tied both facial arteries, but without much improvement.

Case 8.—Ziehl. *Virchow Archiv.*, Bd. xci., s. 92, 1883.

A boy of 4 years presented hypertrophy of the right side of the face which had existed since birth. Four or five weeks before her confinement the mother had been stung by nettles on the right side of the face. At five weeks old the child was convulsed, due to hydrocephalus. Subsequently fits were frequent. The enlargement affected the lower half of the right side of the face. The brow, skull, eyebrows, eyelids, and lashes were unaffected, but the hair on the right side was stiffer and coarser than on the left. There was convergent squint of the right eye with prophthalmos. The right iris was larger than the left, and the right ear longer and broader. Brown pigment spots were present at many places in the face. The alveolar processes of the upper and lower jaw were enlarged, but the teeth were equal on both sides. The right half of the tongue and right tonsil were much enlarged, and there was increased salivary flow from the right side of the mouth.

Motility and sensibility normal. The right hand was larger than the left.

Case 9.—Schieck. "Ein Fall von einseitiger Gesichts-hypertrophie," *Berlin Klin. Wochenschrift*, 1883, p. 200.

The patient was a girl 9 years old, born of a family with no neuropathic tendency. Nothing abnormal was noticed at birth.

At the end of the second year there appeared an increasing swelling of the left cheek and upper lip. At the same time further development of teeth in the upper jaw of the same side ceased. The child was obtuse mentally. At 9 years the overgrowth affected the soft parts of the left cheek and upper lip, and to a less degree the left lower lid. The left nostril was thicker than the right. The lower part of the face and the philtrum of the upper lip were pushed over to the right side.

The left cheek was redder, and the growth of hair distinctly stronger. Sweat and sebaceous secretion not increased. Of the

bones the zygoma, the body of the left maxilla, and particularly the left upper alveolar process were more strongly developed than the right. The left upper jaw contained only the two incisors, canine and first premolar. The lower jaw presented nothing abnormal.

The left half of tongue and left tonsil not enlarged. Left ear and brow normal. Growth of hair on both sides of skull equal, as also pupils. Motility and sensibility normal.

Case 10.—Eve. *Transactions Pathological Society*, vol. xxxiv., 1883.

A woman of 34 had congenital hypertrophy of the foot and leg on the left side, which had rapidly increased.

The left half of the head and face were also larger, as was the left half of the tongue.

The autopsy showed symmetrical enlargement of the left side of the brain, with several osseous growths, the size of peas, in the dura. A fibrous tumour, the size of a filbert, grew from the outer side of the left cornea, and an epulis, the size of a pigeon's egg, from the left upper jaw. The left patella showed hyperostosis.

Case 11.—Finlayson. "Case of a child affected with congenital unilateral hypertrophy. — *Glasgow Medical Journal*, November, 1884.

A female child of 18 months had suffered from repeated attacks of otorrhœa in the right ear. From birth the right side had been hypertrophied throughout. The facial enlargement affected the bones as well as the soft parts. The parietal protuberance was excessively developed, as also were the upper and lower jaws. The tongue on right side and right tonsil were larger. The palate and uvula were normal. The temperature on the right side of the face was 3° to 4° higher than on the left. Teething was precocious on the right side.

On the left side the index, middle, and ring fingers were hypertrophied. Most excessive, however, in size was the middle finger of the right hand.

Under the excitement of crying, patches of colour, red, purple, or blue, come out over the skin in the vicinity of the navel, on the inner and posterior aspects of the hypertrophied right leg, and on the back. The patches suggest cutaneous nævi. The discolouration fades as the child becomes quiet.

Case 12.—Lewin. "Studien über die bei halbseitigen Atrophien und Hypertrophien, namentlich der Gesichts vorkommenden Erscheinungen, &c."—*Charité Annalen*, Bd. ix. s 619, 1884.

A man of 26 showed crossed hypertrophy, affecting, on the left side, the face, neck, and arm, and on the right side the leg, which was longer and thicker than the left.

In the face the hypertrophy concerns the soft parts, and to a less extent the bones, viz., the frontal, zygoma, and upper and lower jaws. The hypertrophy is limited, vertically by the middle line, and otherwise by a line from the middle of the brow to the upper insertion of the auricle.

The skin over this area is hyperæmic, of a bright red colour, and hyperidrotic. The conjunctival and pharyngeal mucous membrane are also hyperæmic, and so is the left half of the hard and soft palate. Tongue and teeth normal. Hyperæmic patches are present on the chest, and flecks of vitiligo are present on the left half of the abdomen, reaching to the middle line, but not passing beyond it. Nævi melanoides are present on the left side of the neck. The sensibility to temperature is diminished on the right side, and general sensibility on the right side of the tongue only.

Left-sided toothache had been frequent since childhood.

The temperature was lower by $\frac{6}{10}$° C. in the left axilla, though the patient had often a subjective sense of warmth on this side.

Case 13.—Humphrey. "Annals of Surgery," vol. iii., 1886.

A boy of 12 suffered from unilateral hypertrophy of the gums of the lower jaw on the left side, which were thicker than those on the right.

There was no discoverable difference between the bones of the two sides of the head and face, but on the left side the tonsil and soft palate were larger than on the right. The upper and lower lip on the left side, protruded and everted, were thick and coarse. The left eyelid was larger and the eyelashes longer than the right, and the hairs of the left eyebrow were coarser and more numerous. The pinna of the left ear was larger and thicker than the right. The hair of the scalp came down lower in front of the ear, and the skin of the face was fuller and more covered with hair. The papillæ on the left side of the tongue were also larger.

The second digit of the left foot and the right thumb were abnormal, ending in soft bulbous extremities.

Case 14.—Masméjean. "Thèse de Montpellier," 1887-8 (quoted by Sabrazés and Cabannes).

An infant of 13 months had hypertrophy of the right side of the face, and of the limbs on the right side. The hypertrophy did not affect the length of the limbs, but only their thickness. The augmentation appeared to be chiefly due to an increase of fatty tissue.

Case 15.—Kiwull. "Ein Beitrag fur Casinstik der halbseitigen Gesichts-hypertrophie." *Fortschritte der Medicin*, 1890, Bd. viii.

A girl of 18 showed right-sided hypertrophy of the face, which was congenital, and progressive. It affected both the bones and the soft parts.

There was bossing of the right frontal bone and prominence of the supraorbital ridge. The upper and lower jaws were enlarged and the surface of the latter was irregular and rough. The right alveolar processes were twice as large as the left. The teeth were widely spaced apart, the lips greatly thickened, and the ear enlarged. A zone of hyperæmia extended obliquely to the right from the middle of the nose for a distance of 2 cm. The right half of the tongue was three times its normal size, and the right tonsil also enlarged. From the right angle of the mouth ran a constant flow of saliva. Taste was blunted on the right side of the tongue, but sensibility of the face was unaltered. Portions of the skin and lip were removed for cosmetic reasons.

On examination, the various layers of the epidermis and cutis were of normal thickness. The sebaceous glands were hypertrophied, and the hair follicles normal. The fatty and connective tissues were increased in bulk, the former beneath the skin, and the latter beneath the mucosa. This latter, made up of fine fibres with few cells, was traversed by dilated veins and arteries. The muscle fibres took but slight part in the overgrowth.

Case 16.—Tilanus. *Munchener Medicinische Wochenschrift*, No. 4, 1893.

A girl of 10 had hypertrophy of the right side of the body, including the face. It was not noticed at birth, nor till the child was 3 years old. It had increased considerably of late.

The facial enlargement concerned the cheek, which was thicker and wider, and the right half of the tongue. The cranial circumference was also increased on the right side. The right shoulder, arm, half of trunk, buttock, leg and foot, all showed overgrowth. The musculature on this side was more powerful.

Electrical reactions and reflexes normal. There was a reticulated marbling of the skin of the trunk and limbs. Under the influence of cold the colour of the marbling became darker, and even blue.

The author thinks it possible that a central cause may be at the root of the overgrowth, and refers to the case of Demme.

Demme's case (*Wiener Medicinische Wochenschrift*, No. 2, Jahrgang xiv., 1891) was one of congenital unilateral hypertrophy in a baby girl who lived only a few days. The hypertrophy affected the whole of the left side of the body. On autopsy the cross sections of the cerebral hemisphere on the left side were larger than those on the right. The muscle fibres on the left side were hypertrophied on cross section, and the nuclei of the sarcolemma increased in number, and arranged in rows.

Case 17.—MONTGOMERY. *Medical News*, vol. ii., 1893, p. 61.

The patient was a man of 31, of German extraction. At 2 years he had brain fever. At 8 or 9 an alveolar abscess formed on the left lower jaw and caused much pain. No neuralgia. No abnormality of dentition.

A photograph taken at 5 shows the face to be perfectly symmetrical.

At 10 the gums were noticed to be enlarged, and at 12 the deformity was noticeable on the left side of the face.

At 31 the deformity occupied an irregular quadrilateral enclosed internally, by the mesial line from the anterior extremity of the sagittal suture, down to the mental symphysis, below by the border of the lower jaw and on to the tip of the mastoid, and posteriorly from the mastoid to the sagittal suture. The hypertrophy is most marked in the supraorbital, molar, and mental regions, where the tissues are raised up into tumefied masses consisting of soft parts and bone. The frontal bone shares in the hypertrophy, a mass of bone running upwards and backwards over this region from the outer extremity of the supraorbital ridge.

The scalp and hair are normal. The upper half of the left ear is hypertrophied. The discs are excavated, and not engorged. The left lower jaw is enlarged and roughened. No enlargement of teeth, tongue, or tonsil. No sensory abnormality, general or special. The deformity is progressive.

Portions of skin removed for æsthetic purposes showed, on section, increase in the size of the hairs and sebaceous glands. Also plugging of the sebaceous glands with sebum, and degenerated cells. There was no increase in connective tissue, or fat.

Case 18.—Dana. *Journal of Nervous and Mental Disease*, November, 1893, page 234.

The patient was a professional giant of 19. Height 7 ft. 4 in., weight 325 lbs.

Acromegaly was present, the hands and feet being enormous. He "wore a shoe just a foot and a half long." The enlargement was symmetrical in both upper and lower extremities. The left half of the face was hypertrophied, the enlargement having begun at puberty, and being progressive. It corresponded closely with the distribution of the left trigeminus, and involved the upper and lower jaw, the alveolar processes being enormously enlarged, as also the palatal arch. The teeth were normal, and so were the orbits, but the left frontal bone showed great bulging.

No pigmentation. Muscular system moderately developed, but the patient was weak. Vision good. No contraction of fields. Pupils normal. Intelligence good. Appetite prodigious.

Case 19.—Heath. "Injuries and Diseases of Jaws," 1894, page 136.

A boy of 12 showed enlargement of the face, which was noticed at three months old. It affected the bones and soft parts on the left side.

The superior maxilla on this side retained in its alveoli the temporary incisors and canines, but these had been replaced by permanent teeth on the sound side.

Mr. Heath removed the superior maxilla, but the patient's condition, two years later, was as unsightly as before.

Case 20.—Arnheim. "Hypertrophie congénitale de la moitié droite de la face et du bras correspondant."—*Semaine Medicale*, 1895 and 1897.

A girl of 4 months exhibited congenital hypertrophy of the right side of the face and the corresponding arm. The hyperplasia of the face formed a prominent mass, which raised the left lip.

The right half of the tongue was enormously hypertrophied, and the right ear was larger by 1 cm. than the left. The right arm also longer than the left.

Dyspnœa was present, of cardiac origin.

At 2 years the child died of broncho-pneumonia. The autopsy showed that the hypertrophy extended to the internal organs on the right side of the chest. The right auricle and ventricle were larger than the left, and the right bronchi more spacious.

Case 21.—SABRAZÈS and CABANNES. "Hemi-hypertrophie faciale."—*Nouvelle Iconographie de la Salpêtrière*, tome xi., 1898.

A boy of 3 years presented congenital hypertrophy of the right side of the face.

At the fourth month of pregnancy the mother suffered a fall on the abdomen, and at the seventh an emotional shock. At four months the child had a purulent otorrhœa (right), which lasted two months, and left impaired hearing. Dentition was precocious on this (right) side. The original disproportion has been maintained since birth.

It concerns the bones and soft parts, and the frontal boss is enlarged. The cranium is asymmetrical, showing increased development and fulness on the right side. Venous dilatations are present on the mucous surfaces of the left cheek.

In the median line in the occipital region there is present in the scalp a pigmented streak, cafe-au-lait colour, extending from the nape of the neck to four fingers' breadth below the summit of the vertex; over this streak the hair exhibits a negroid curliness.

Electrical examination shows on the left a normal reaction, and on the right a diminution of excitability, owing to the increased resistance of the tissues.

Sensibility to pain is diminished slightly on the affected cheek. On the forehead it is the same as on the opposite side. The gustatory sense is normal. The pharyngeal and palpebral reflexes are normal.

The right cheek always redder than the left, becomes scarlet when the patient approaches the fire. In winter it is more sensitive to cold, and suffers from cracks.

The right hand is slightly larger than the left.

Case 22.—HERMANIDES. "Een geval van hemi-hypertrophia congenita."—*Psychiatr. en neurol., Bladen*, 1899. (Abstract in *Mendel's Centralblatt*, 1900, p. 912.)

In a child of 13 months all parts of the left side of the body were larger than the right. The palpebral opening, eyeball, and pupil, appeared to be somewhat larger on the left side. As a rule the left ear was redder than the right. A striking difference obtained between the two halves of the tongue, but the small right half showed fibrillary twitchings, and the mucous membrane was thrown into small folds. Trophic signs were absent, apart from the increased reddening of the left ear. The teeth and hair on both sides were equally developed. Sensibility was equal on both sides, and no difference could be detected in the sensibility.

It appeared, at first, doubtful whether in this case the condition was one of left hypertrophy or of right hemiatrophy, but the author is satisfied that the former was the real condition.

Case 23.—HUTCHINSON. *Polyclinic*, July, 1901.

The patient was a middle-aged woman with unilateral hypertrophy of the face and skull. The soft parts did not appear excessively increased, but there was enlargement of most of the bones in the right half of the face. The frontal boss on the right side was specially prominent, and the right eye bulged forward, probably on account of a growth behind it.

There is no statement as to whether the condition was congenital or not.

Elsewhere the patient showed multiple cutaneous and subcutaneous fibromata scattered over the chest, and also osseous enlargement of the left side of the sternum, involving possibly some of the ribs.

Case 24.—RAPIN. "Sur une forme d'hypertrophie des membres (Dystrophie conjonctive myélopathique)." *Nouvelle Iconographie de la Salpêtrière*, No. 6, 1901.

The case was a congenital one, in a woman of 29. The hypertrophy concerned the right side of the face and the two upper limbs. In the face it affected the cheek and ear on the right side. The maxilla showed no thickening. The teeth were bad. There was no nævus or vascular tâches.

The two arms were equally enlarged. The hypertrophy commenced about the middle of the limbs, but was most marked in the hands. The skin was white, soft to the touch and normal. There were no abnormal vessels on the surface. Under the influence of cold it became quickly cyanotic and stiff.

Palpation gave the impression of moderately firm fatty tissue. It did not pit on pressure. Cutaneous sensibility was normal.

Case 25.—HERTOGHE. "Contribution a l'étude de trophœdème chronique." *Ibid.*, page 497, 1901.

A girl of 21 shows congenital hypertrophy of the right cheek. The tongue is not increased in size, but the papillæ on the affected side are hypertrophied. The teeth are more strongly developed on the affected side. On this side the wisdom tooth is through and well established, but not on the healthy side. The palate on the right side is larger, and its rugosities are more marked. The hairs on this side are hypertrophied.

The bones of the face are not affected, but the middle turbinate is hypertrophied as compared with the sound side.

A sister of the patient shows infantilism at 15 years, and has the lower limbs "en colonnes," the legs being as thick as the thighs. The mother suffered from lipoma of the arm.

Case 26.—THOMAS. "Deux cas d'hemihypertrophie congenitale du corps." *Ibid.*, page 508, 1901.

A female child of four months has congenital hypertrophy of the face and one half of the body. The hypertrophy affects the right cheek, which is plumper and thicker than the left. The skin also appears thicker. The palpebral aperture is wider on the right, but there is no anomaly in the eyes, ears, nose, or mouth. The right half of the tongue is much larger and thicker than the left. Palate and soft palate normal.

The bodily hypertrophy affects the trunk and limbs of the left side. The bones are enlarged as well as the soft parts, and the muscles also participate. The skin is thicker on the affected side.

The hypertrophy is more pronounced in the thigh than in the leg and foot. Coloration, temperature, and sensibility normal.

Two years later the child was examined again. The hypertrophy was still present, but was much less apparent. Teething was delayed, the child at this date having only six.

Case 27.—THOMPSON. *Transactions Med. Chirurg. Soc. of Edinburgh*, vol. xxi., page 204, 1901-02.

In a young woman of 27 enlargement of the left cheek, with hyperostosis of the left upper jaw and malar bone had existed, probably since birth.

The hyperostosis affected the entire upper jaw, except its alveolar margin, and the downward projection of the alveolar margin caused obliquity of the oral fissure. The nose deviated to the opposite side owing to overgrowth of the nasal process.

Case 28.—FOWLER. *Ibid.*, 1901-2.

A girl of 3 showed hemihypertrophy of the right side, affecting the face, arm, thorax, and leg. The distal parts were more hypertrophied than the proximal.

The temperature was higher on the affected side, and the eruption of teeth was earlier. Numerous capillary nævi were scattered over the body.

Case 29.—MACKAY. Unpublished.

A girl of 10 suffers from acquired hypertrophy of the left side of face and skull. The child was normal at birth, and a portrait taken at 5 shows no asymmetry of the face. Measles occurred at 8, followed by earache and otorrhœa, and the latter complaints have been frequent since. There has been no general headache, and no trigeminal neuralgia. Memory and intelligence are good. Bodily symmetry is elsewhere perfect, except that the left hand is somewhat larger than the right. The deformity was noticed first at 6 years of age as a bony enlargement on the head near the vertex. Then appeared a similar swelling in the occipital region. Then came a fulness in the forehead, and, lastly, the cheek began to enlarge.

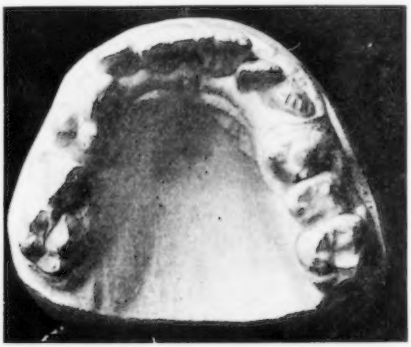

FIG. 4.

Cast of upper dental arch, showing hypertrophy of left alveolar border and teeth. The hypertrophy is sharply defined by the mesial line.

The child is of average build and well nourished. Height 4 ft. 5 in., weight 68 lbs. The bony skeleton elsewhere than in the affected parts is normal. There is no sign of rickets or of congenital syphilis. The teeth are mostly carious. The facial enlargement is limited strictly by the middle line. The left cheek is fuller and thicker, also the left upper and lower lips. Left nasal bone is thickened. Soft parts of nose on left side hypertrophied, and also the left half of the chin.

The bony overgrowth extends to all the left facial bones, and

FIG. 1.

Hemihypertrophy of face and cranium.

FIG. 2.

Left side view, showing frontal and parietal bossing.

FIG. 3.

Normal side.

to most of the cranial, *e.g.*, the frontal, parietal, sphenoidal (orbital plate, probably), temporal and occipital.

There is marked bossing of the frontal, a smooth prominence of bone commencing at the inner end of the supraorbital ridge, and passing upwards over the middle of the bone to the hairy scalp, where it ends.

Another bony ridge commences to the left of the sagittal suture near the vertex, and runs downwards and forwards over the left parietal bone.

A third mass in the form of a rounded boss occupies the superior angle of the occipital bone posterior to the fontanelle. This boss is mesial in position. In the parotid region the enlargement of the malar and zygoma give rise to a fulness suggesting mumps. The superior maxilla is greatly enlarged, and also its alveolar border. The molars are longer and thicker on this side. Behind the ear the mastoid and the adjoining portion of the temporal bone are enlarged.

Exostoses project from the tip of the mastoid, and from the posterior free border of the superior maxilla.

The posterior part of the skull on the left side is also enlarged, and the hair covering this portion is coarser than on the right. Tongue, palate and tonsils are normal. In the left eye the sclerotic in the lower and outer quadrant of the ball is bulged forward, probably owing to some pressure from behind. The rim of the orbit is thickened. Owing to the pushing forward of the outer part of the ball an internal squint, not congenital, has been developed.

Ophthalmoscopic (left eye).—The media are clear, but there is œdematous swelling of the disc, with haziness of the margin, everywhere except in the lower nasal quadrant. The retinal vessels are obscured by the swelling. On the temporal side the retina is swollen and hazy.

Vision R. $\frac{6}{6}$, J.1 at 22cm.; no H.M.
L. $\frac{6}{36}$, J.20; not improved by glasses.

The F. of vision, normal in the right eye, is contracted in the left to the nasal side.

Hearing on the right side is normal, but on the left the watch-tick is heard on contact only. There is an old perforation of the drum.

The special senses are otherwise normal.

Ordinary sensibility to touch, pain, and temperature is unaffected.

Motility and reflexes are normal.

There are no vaso-motor signs, increased sweating, dilated vessels, flushing, or hypersensitiveness to cold. No salivation. There is, however, hypertrichosis of the left cheek in the neighhood of the ear.

Electrical reactions normal.

Stilling's cases are briefly as follows: ("Untersuchungen über die spinal Irritation." Leipzig, 1840, S. 337).

(1) A man of 48 had been thrown when 23 years of age from his horse, injuring his face. Since then the cheek (right) had been larger than the other. Subsequently the same cheek was gored by the horn of an ox. At the time of examination the right cheek was the size of a small child's head. It was soft and smooth and not painful on palpation. At several places small telangiectases the size of raspberries were present. The skin was anæsthetic over an area which was sharply defined. Movement was also lost on the affected side. The tongue and oral mucous membrane were normal. So were the special senses. No pulsation, but the arteries collectively on the affected side, and apparently the carotid, too, were markedly enlarged.

(2) A woman of 38, when nine years old, was struck by a stone on the right cheek, and lost much blood from the mouth. A swelling gradually developed which resisted all treatment. It was the size of a man's fist and limited itself exactly to the right cheek. The skin felt soft, and had the same healthy red colour as the other side. The swollen mucous membrane protruded on the right angle of the mouth showing several enlarged dark coloured blood vessels. Much saliva escaped, which Stilling considered to be serous exudation from the enlarged blood vessels in the mucous membrane. The oral mucous membrane covering the cheek was of a dark blue-red colour, tumid and swollen, with numerous distended blood vessels.

Sensation, motility and reflexes normal. The facial bones were not affected.

When the patient held herself bent over, the swelling became larger and more distended.

The temperature was the same on both sides, and no pulsation was present.

Digest of Clinical Features.

Females are affected oftener than males, in the proportion of 17 to 12. The right side is hypertrophied oftener

than the left, in the proportion of 15 to 12. This accords with St. Hilaire's (63) opinion regarding unilateral hypertrophy of the body. There is no evidence of hereditary transmission. "Maternal impressions" figure on three occasions.

In twenty-three cases the condition was congenital, or was probably so. In six there is good evidence that it was post-natal, or "acquired." The latter form has appeared at ages varying from 6 to 55 years.

As regards personal antecedents, in four cases (Nos. 2, 3, 21, 29), there has been otorrhœa on the same side as the hypertrophy. In the former three, congenital cases, the otorrhœa could not well have preceded the overgrowth. In the latter case it did. In four other cases there has been present some peripheral irritation of the trigeminal nerve, from frequent toothache (Nos. 2, 12), or from obstinate neuralgia (No. 5), or alveolar abscess (No. 17). In the two former cases the temporal relation of the pain to the hypertrophy is not stated. In the two latter the pain preceded the overgrowth.

In the majority of cases, 19 out of 29, the hypertrophy has been limited to the face, or the face and head. In the remaining ten other parts of the body have been affected also. Of the nineteen former cases, in three (Nos. 1, 5, 25) the soft parts of the cheek were alone affected, in sixteen the facial bones shared in the hypertrophy. In eleven of these the cranial bones were also involved. In three additional cases (Nos. 20, 24, 26) the soft parts of the cheek were hypertrophied, but in conjunction with segmental overgrowth of some other part of the body.

In three cases (Dana's case, and the skulls belonging to Mr. Hutchinson and Dr. Thompson),[1] and also in the two cases of hemicraniosis recorded by Brissaud and Lereboullet, it is stated that the parts affected corresponded exactly to the distribution area of the fifth nerve. As a matter of fact, however, this correspondence with the trigeminal area, either in whole, or in part, appears in every recorded case of

[1] *Vide infra.*

facial hypertrophy. In one case only have the limits of the trigeminal been transgressed, viz., in case 29, where an occipital boss was present.

This relation of hypertrophy to peripheral nerve area is scarcely to be wondered at when we recall that, with the exception of the parotid region, supplied by a branch of the great auricular, the trigeminal supplies practically the anterior two thirds of the cephalon. In the light of Brissaud's (46) observations on the influence of metamerism in nervous disease it is interesting to note that according to Gegenbauer (40), the trigeminal though a single peripheral nerve represents the complete sensory fibres appertaining to the first complete cranial metamere.

As regards the bones, those most frequently hypertrophied were the maxillæ, one or both being enlarged, either in part, or wholly, in 17 cases out of 29. When, as happened in three cases, one maxilla only was affected, it was the upper one that was selected.

In connection with this preference for the maxillary bones it is noteworthy that, as Professor Dixon has pointed out,[1] a similar selection takes place in acromegaly. Professor Dixon calls attention to the fact that the pituitary body is developped partly from the neural tube, and partly from the buccal cavity, and that when this body is diseased, as in acromegaly, the first bones to be enlarged or affected are those developed as membranous bones in connection with the primitive mouth, or stomodæum, *i.e.*, portions of the superior and inferior maxillæ.

Of the cranial bones the one most frequently affected was the frontal, which displayed bossing in six cases. In two more the parietal also showed enlargement, and in one (No. 29) the occipital showed a mesial boss. In three cases there was uniform unilateral enlargement of the cranial bones, without bossing. Thus in 11 cases out of 29 the osseous hypertrophy was hemicephalic rather than hemifacial.

Coming now to the cases in which the trunk and

[1] British Medical Association Meeting at Oxford, 1904. Discussion on Professor Cunningham's paper. Anatomical section, July 27.

appendages shared in the overgrowth, in five of the ten observations the hypertrophy was unilateral, affecting the limbs or the limbs and trunk on the same side as the face (Nos. 11, 14, 16, 22, 28). In one (No. 20) the upper limb only, on the same side, was affected.

In two the distribution was crossed, affecting either the face and arms on one side, and the leg on the other (No. 12), or the face on one side and half the body on the other (No. 26). In one (No. 24) the lower segments of the two upper extremities shared in the hyperplasia, along with half the face, and in one (No. 18) the facial hemihypertrophy was associated with acromegaly and giantism.

In addition to the cases already mentioned where the distribution of the hypertrophy in the appendages was segmental—*i.e.*, was limited by a boundary line, running at right angles to the long axis of the limb—the same feature was present in Case 26, where the thigh showed more marked enlargement than the leg and foot of the same side, and in Cases 21 and 29 where one hand, on the same side as the face, was enlarged in each case (cheiromegaly). A segmental distribution of the hypertrophy of the appendages was thus present in seven cases out of twenty-nine.

Unilateral enlargement of the tongue occurred in eleven cases. In six the corresponding tonsil was enlarged, and in five the teeth shared in the hypertrophy.

Cutaneous pigmentations, nævi or marbling of the skin, were present in seven cases. In one (No. 7) there was a patch of dark horny ichthyosis near the ear, and in one (No. 12) spots of vitiligo were scattered over the abdomen, on the same side as the hypertrophy, their distribution being bounded by the middle line.

Vaso-motor, or sympathetic, disturbances, such as hyperidrosis, excess of saliva, cutaneous hyperæmias, localised elevations of temperature, and excess of sebaceous secretion, are noted in seven cases (Nos. 2, 8, 9, 11, 12, 15 and 21).

Coarseness, or abnormal growth of hair, a trophic, probably, rather than a vaso-motor, symptom is reported in six cases (Nos. 2, 3, 8, 9, 13, 29).

As regards nerve function, motility and general sensi-

bility are usually stated to be normal, but the latter was diminished in two cases (Nos. 12, 21). Subjective sensations of warmth, or a special sensitiveness to cold, with a cyanotic change of colour, under its influence is reported in five cases (Nos. 2, 12, 21, 16, 24).

Dissociation of sensation does not appear to have been looked for, unfortunately, in the majority of the recorded cases. In Lewin's case (No. 12) it was present.

The special senses were but seldom affected.

In two taste was blunted, and in one (No. 29) sight and hearing were damaged on the affected side. The defect of sight in this case was associated with neuro-retinitis, apparently due to pressure by osteophytic growth on the back of the ball, and the deafness was connected with chronic otorrhœa.

Prophthalmos was present in three cases (Nos. 8, 23, 29). The reflexes and electrical reactions were generally normal, and intelligence was usually unaffected.

In five cases the hypertrophy was progressive to a greater degree than the bodily growth (Nos. 1, 15, 17, 18, 29). In one (No. 26) it was retrogressive. This case, however, was an instance of the so-called chronic trophœdema.

Although, following the current nomenclature, the cases described here are distinguished as "congenital" and "acquired," it may be questioned whether the distinction is pathologically a valid one. That the condition is in the biological sense always acquired is evident by the fact that its hereditary transmission is unknown.

Even on clinical grounds it appears to be impossible—apart from the mere date of commencement—to separate between the two classes. Sabrazès and Cabannes are of opinion that a distinguishing feature may perhaps be found in the date of the dental evolution, which they consider to be delayed in the "acquired," and precocious in the "congenital, cases." But in the cases of Heath and Thomas (Nos. 19 and 26), which were "congenital," the dental evolution was retarded. Again, the unilateral enlargement of the tongue, which these authors consider to be usually absent in "acquired" cases, was present in that of Tilanus (No. 16), which was "acquired."

It does not appear possible, therefore, either on clinical or biological grounds, to maintain the distinction, and it would be more logical to consider the morbid conditions in both classes to be the outcome of some disease process common to them both, the date of commencement having been prenatal in one class and postnatal in the other.

Pathology.

Post-mortem observations of the condition may be said to be non-existent. In no case have the nerve centres been examined by modern methods.

Portions of soft tissues removed during life have shown as histological conditions, overgrowth of sebaceous and sudoriparous glands, and of adipose and connective tissues, with numerous degenerated epithelial cells.

The osteopathic changes have been well described by Mr. Jonathan Hutchinson and Dr. Alexis Thompson, and excellent illustrations of the conditions present in their specimens are given in Bramwell's "Atlas of Clinical Medicine," vol. III.

Both skulls show the over-development of bone to be limited strictly to the territory of the trigeminal.

Mr. Hutchinson describes the condition as one of overgrowth of bone, with broad-based exostoses. The overgrowth involves the frontal and sphenoid, as well as the facial, bones proper.

The hypertrophy in this case was said to have become conspicuous in middle life, but Mr. Hutchinson is of opinion that the case was probably congenital. Dr. Thompson's specimen was obtained from an insane patient who has been the subject of epilepsy since childhood. The overgrowth appeared to have commenced in early life, and not to have been congenital. It affected all the facial bones, and the anterior two-thirds of the cranium on the left side.

The convolutions on the anterior and superior aspect of the frontal lobe on the same side were atrophied by the pressure of a large exostosis projecting from the inner table of the frontal bone. To this Dr. Thompson attributes the

epileptic seizures which occurred during life. A similar condition is described in the autopsy on Friedreich's case already referred to (No. 2), and in the second of the cases reported by Brissaud and Lereboullet (62).

Pathogeny.

In the absence of pathological fact it is natural that speculation as to pathogeny should be exuberant.

The following theories are among those that have been put forward :—

(1) Vaso-motor.—The overgrowth being the result of vaso-motor paresis throughout the affected part, causing vascular dilatation and consequent hypernutrition and hypertrophy. With this view must be associated the theory of sympathetic irritation which has been favoured by several observers, *e.g.*, Barwell (20) and Hermanides (38).

The vaso-motor theory has the support of many writers, such as Trelat and Monod (5), Ziehl (10), Leblanc (41), and others, who base their opinions on the well-known experiments of Claude Bernard and Schiff (42), and on the observations of Stilling (14). In its favour may be cited the frequent vaso-motor derangements, vascular ectases, cutaneous hyperæmias, alterations in surface temperature, salivations, local sweatings, &c., which have been recorded in connection with the condition.

Both the vaso-motor and the sympathetic theories, however, only put the chief difficulty one step further back, as they do not explain why the vaso-motor paralysis, or sympathetic disturbance, arises.

Moreover, it must be noted that in many cases of facial hypertrophy, *e.g.*, those of Fischer, Dana, Montgomery, and my own, there has been a complete absence of vaso-motor indications of any kind. These considerations suggest that while the vaso-motor mechanism frequently shows signs of being implicated in the disease, it is probable that the implication is a secondary condition only, and that it occurs, when it is present, as the result of some deeper lying primary

disturbance of the central nervous mechanism. A similar relation may be observed in the vaso-motor disturbances which accompany syringomyelia.

(2) The theory put forward by Fischer (9) of circulatory stasis in the affected part, produced by vicious positions of the fœtus in utero, and setting up hypernutrition and consequent overgrowth. Fischer supported his view by the observations of Miram (43) on the existence of hypertrophy in the distal parts of limbs in which congenital furrows were present.

This theory is obviously inadequate, inasmuch as it leaves the postnatal cases unexplained.

(3) Lannelongue's (44) view supposed some unknown stimulus or irritation of epiphysial cartilages and osteoplastic periosteum, which led to the overgrowth, first of bony, and secondly of soft, parts. This, too, must be put aside as insufficient to account for the cases in which the soft parts alone are affected.

(4) Messrs. Sabrazés and Cabannes (*loc. cit.*) have put forward a teratological theory, and consider the facial hemihypertrophy, when congenital, to be of the nature of an "anomaly by excess," which takes place in the frontal buds at an early date of intra-uterine life. They consider also that other factors may come into play, *e.g.*, variations in the size of the nutrient artery supplying the part.

This view, however, again fails to account for the "acquired" or postnatal cases, which, as we have already seen, appear to be not essentially separable from the congenital.

(5) The trophoneurotic theory. Lewin (13) appears to have been the first to put forward the clinical evidence in favour of a trophic, as distinct from a vaso-motor, theory, in accounting for local atrophies and hypertrophies.

The conflict which he mentions as existing then (1884), between the physiologists and the clinicians, regarding the existence of trophic influences generally, appears to be still unsettled.

Thus, Dr. Aldren Turner, in discussing the pathology of "Facial Hemiatrophy" (Allbutt's System, vol. vi., p. 488),

dismisses the older views, including the "tropho-neurosis" theory of Romberg as scarcely worthy of consideration, while Mr. Jonathan Hutchinson, in the most recent discussion of the same subject ("Atlas of Illustrations of Clinical Medicine"—Fasciculus xix., 1904), after demonstrating that in a great majority of cases, if not in all, facial hemiatrophy is a late stage of fifth nerve morphœa, concludes that it is almost certain the primary sclerodermic changes are brought about under the influence of the nervous system, and that to them, therefore, the term tropho-neurosis is undoubtedly applicable.

The difference of opinion need not concern us here. Whatever the views of the physiologists may be regarding the conceptions of trophic centres and trophic influences, it is clear that the clinician and the pathologist, with the facts of syringomyelia and acromegaly before their eyes, cannot well do without them.

It may be well before proceeding further to recapitulate briefly the various forms in which hypertrophy of different parts of the body occurs.

As Anderson (45) has remarked, general, *i.e.*, complete bilateral, hypertrophy of the body is, at present, a possibility only. It may be considered that giantism, when free from taint of acromegaly, and when the bodily proportions are symmetrically preserved, would exemplify this class; but I am not aware of any authentic record of giantism which fulfils these conditions.

Complete unilateral hypertrophy, *i.e.*, of one half of the body, has of course been frequently recorded, as also has the partial unilateral type. In the latter form the face may or may not participate, and the hypertrophy may affect any limb, or segment of a limb, as in podo- and cheiro-megaly.

In the crossed variety of hemihypertrophy, various combinations may occur. The face on one side may be affected, with the trunk and limbs on the other, or the face and upper limb on one side, and the lower limb on the other.

The hemifacial variety of hypertrophy is thus seen to be merely a partial type, which may exist alone, or with which may co-exist any other form or degree of bodily overgrowth.

As regards the period of onset, whilst most instances in each class are congenital it is clear that all are not so. In Tilanus's case of complete unilateral hypertrophy the difference in size was not apparent till the child was 3 years old. In MacGregor's case (*Glasgow Medical Journal*, March, 1894) the partial hypertrophy apparently commenced in the leg at the age of 6, and in the hand at 10. In Montgomery's case, and in my own, photographs of the patients taken in early life show no existing facial asymmetry.

It will be noted that only in the hemifacial type does the area of hypertrophy correspond with the distribution area, complete or partial, of a peripheral nerve. In the bodily types, those, that is, affecting the trunk and limbs, the hypertrophied regions coincide with no area of nerve distribution, peripheral or radicular. The distribution of the hypertrophy is in these cases segmental or metameric, the boundary line, being, in the trunk, at right angles to the spine, and in the appendages, at right angles to the long axis of the limb. This apparent anomaly may perhaps be explained, as has already been suggested, by Gegenbauer's statement that the trigeminal, the nerve-area chiefly concerned in facial hemihypertrophy, represents the (unilateral) afferent fibres of the first cranial metamere.

It is in connection with this segmental distribution of the hypertrophies of the trunk and limbs, and, presumably, of the face as well, that Brissaud's theory of spinal and cerebral metamerism in nervous disease is of interest, through its conception of the cerebro-spinal axis as a series of neural metameres, or myelomeres, corresponding to and controlling as regards some nerve functions, *e.g.*, the trophic, the aboriginal metameric segments of the body.

Equally attractive as a theory, if less well founded on embryological fact, is the suggestion of outbuddings from the neural axis, in the brachial and crural regions, by which it is sought to explain (47) the distribution of those dystrophic conditions which affect segments of a limb only.

If now we enquire whether clinical observation warrants the supposition of a trophic influence inducing local overgrowth, and emanating from the central axis, it must be

admitted that the facts of syringomyelia and of acromegaly support such a view.

While the dystrophies observed in connection with syringomyelia are most commonly of the atrophic type, it is well known that hypertrophic conditions have not infrequently been recorded.

Chauffard and Griffon (48) describe the case of a man of 48, who had observed for some years an augmentation in the volume of the right arm. Along with other signs of trophic disturbance (ichthyosis, hypertrichosis) the right upper limb was enlarged from the shoulder to the fingers, the bones being also affected. Dissociation of sensation was present in the whole length of the hypertrophied limb, and, in addition, in the shoulder, the right half of the neck, and right half of the cranium and face, the area of disturbance in the latter being limited accurately by the middle line. Perspiration was diminished over this area. No symptom of acromegaly was present unless the enlargement of the hand be so considered.

Somewhat similar cases have been described by Marie (49), in which, with syringomyelia there was present hypertrophy of the right arm and left foot, and by Charcot and Brissaud (50), in which enlargement of the left hand alone was present. Although designated "pseudo-acromegalic," the acromegalic symptoms in the above cases were limited to the enlargement of one or more extremities. In Lountz's case, however (51), there was hypertrophy of the right arm, including the bones, no suggestion of acromegaly being present, and a similar case is reported by Heldenberg (52) in which a man of 27, the subject of syringomyelia, developed hypertrophy of the right arm after an attack of acute rheumatism.

These cases show that there is sufficient clinical warrant for asserting an association between some forms of partial hypertrophy of the body, and lesions of the central gray matter of the neural axis.

The absence of hypertrophy of the cranial and facial bones in Chauffard and Griffon's case was remarked on by these authors, seeing that the dissociation symptoms extended to the cranium and face.

FIG. 5.

Radiogram of cranium of acromegalic giant, Charles F., to show "ressaut post-lambdoïdien." Slight facial hemihypertrophy was also present in this case.
(From Launois and Roy's monograph, by kind permission of Messrs. Masson et Cie.)

Hypertrophy of cranial bones, however, in cases of syringomyelia where no acromegaly was present, has been reported by Colman (53), in whose case frontal bossing occurred, by Westphal (54), who reported frontal and parietal thickening, and by Collier (55). In the latter case some enlargement of the parietal bone co-existed with remarkable deformity of the cranium.

It may be recalled that in 6 out of the 29 cases of facial hemihypertrophy here collected, frontal bossing was present, and that in two parietal thickening occurred as well.

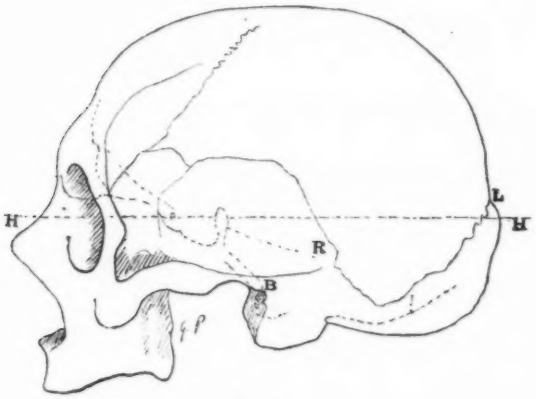

FIG. 6.

Acromegalic cranium in the Ecole d'Anthropologie, showing "ressaut post-lambdoidien" (Papillault).
(From "*Nouvelle Iconographie de la Salpêtrière*," vol. xv., p. 581, by kind permission of Messrs. Masson et Cie.)

The possible relationships between syringomyelia and acromegaly is a subject far outside the bounds of this communication, but in connection with the latter disease I wish to draw attention to the occipital boss reported in Case 29 of the present series. There is, so far as I am aware, no previous record of hyperostosis of the occipital bone in connection with facial hemihypertrophy. Its occurrence in this case appears to me to be of interest, as suggesting a possible link of relationship with acromegaly.

F. Schultze long ago called attention to the occasional prominence of the external occipital protuberance in this disease. Papillault later (56) described the so-called "*ressaut post-lambdoidien*," a bony overgrowth situated posterior to the lambdoid suture, the gradual development of which he had studied in the acromegalic giant Charles, and which he had also found present in an acromegalic skull.

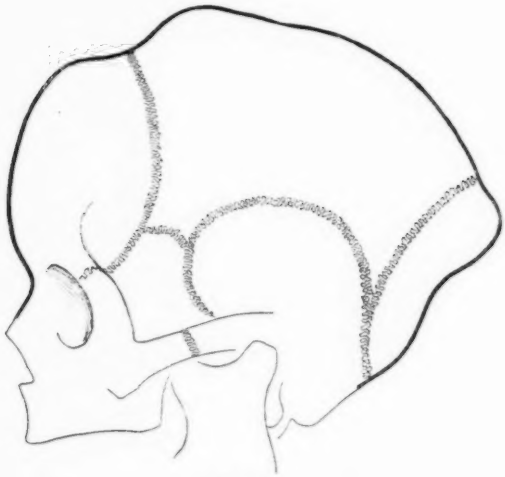

FIG. 7.

Tracing of skull in Case 29, taken by a strip of lead a little to left of mesial line, showing frontal, parietal, and occipital bossing ("ressaut post-lambdoidien"?) The thin lines and suture markings are diagrammatic.

From a comparison of a radiogram of the cranial bones in Papillault's case, with the condition present in Case 29, I am of opinion that the occipital boss in this case is of the same nature as that described by Papillault (see figs. 5, 6 & 7).

A further illustration of the relationship I have now ventured to suggest exists in Dana's case (No. 18), in which the two conditions of facial hemihypertrophy and acromegaly were present in the same individual. Another instance of the coincidence of these two conditions is recorded by Launois and Roy (64). In their account of the acromegalic

giant, Charles F., these authors remark that facial asymmetry was present, the right half of the face being a little less developed than the left half. The patient himself had noticed that for the two months previously the left cheek projected more prominently than the right.

Dana remarks of his case that it might correctly be described as one of somato-megaly with hemiacromegaly of the head. Having regard to the frequency with which the cranial bones are affected, it would appear that some such term as hemicephalomegaly would express more accurately than facial hemihypertrophy the actual condition present, not only in Dana's case, but in many of the cases described in this paper.

The condition of chronic trophœdema, described by Meige in 1898 (57), is one that cannot be left out of account in future studies of facial and other hypertrophies.

Following Meige and his school, this may be described as a chronic enlargement, affecting, without prejudice to the health, one-or more limbs, or segments of these, including it may be, one half of the face; presenting outwardly the appearance of an œdema, but characterised by absence of pitting, of pain, and of colour. Sensory troubles may be present, and in one case at least [Mabille (58)], dissociation of sensation has been observed.

The condition may be hereditary, or familial, congenital, or acquired.

Meige ascribes the condition to hyperplasia of the subcutaneous connective tissue, considers that it is related to the hypertrophic conditions met with in syringomyelia, and that it is due, pathologically, to changes in the trophic centres located in the central gray matter in the neighbourhood of the trophic centres for muscles. The local hyperplasia may not be limited to cellular tissue, that of fatty tissue may also occur. In the case of muscle, hypertrophy may also occur, though as a rule the muscular dystrophy takes the atrophic form.

As I have already suggested, it appears probable that some of the recorded cases of facial hemihypertrophy, those, namely, in which the soft parts alone have been affected, may

have been conditions closely allied to, if not identical with those described as facial trophœdema by Rapin and Hertoghe (*vide supra*).

It is difficult in considering the pathogeny of acquired facial hemihypertrophy to avoid reference to the contrasted condition of acquired facial hemiatrophy.

Mr. Hutchinson's views upon this subject, founded upon Unna's account of the histology of the tissues in a case of scleroderma, have already been alluded to. Mr. Hutchinson is of opinion that the original local hyperplasia of subcutaneous fibrous tissue which is the essential change in the first stage of scleroderma, is of the nature of a trophoneurosis. The resultant arrest of growth in the lateral half of the face which constitutes facial hemiatrophy is thus to be assigned, if not directly, yet remotely and indirectly, to some disturbance of trophic, or nutritional, control akin to that which appears to underlie the changes in facial hemihypertrophy.

While the view that facial hemiatrophy is really an arrest of growth consequent on antecedent morphœa is doubtless true of all cases in which the atrophic changes have been observed before, or soon after, the cessation of period of adolescence, some doubt of the universal truth of this explanation will arise in connection with those cases in which the facial atrophy has commenced at mature age. Such are Bramwell's case of J. D. (59) in which the atrophic signs appeared first in a man of 40, and Hoffmann's case (60), where the first signs appeared in a woman, the subject of inveterate neuralgia, at the age of 42. In these cases the question of arrest of growth can hardly arise. Whether preceded by unobserved sclerodermic changes or not (and none were observed in either case), we have to recognise that at ages such as these there can only be retrogressive changes of formed adult tissues.

If we consider that in cases such as these we have pathologically, the converse condition to that which is present in facial hemihypertrophy, we may go further, and find a close parallel to the condition of acquired unilateral hypertrophy in the three remarkable cases described by Raymond and Siccard (61).

In two of these, concerning a brother and sister aged 30, and 35, respectively, progressive atrophy of one side of the body had been observed, extending from below upward, and involving in succession the leg, thigh, abdomen, thorax, upper extremity, shoulder, and one half of the face, the general health meanwhile remaining unaffected.

It is difficult to avoid in these cases, the conclusion arrived at by the authors themselves, that the condition is one of a trophoneurosis consequent on changes in the neural axis.

The following conclusions appear to be warranted by the considerations now put forward: (1) While nothing is known of the pathogeny of facial hemihypertrophy, the most reasonable explanation of the condition is that which associates it with disturbance of hypothetical nutritional or trophic centres, in the periependymal gray matter of the encephalon.

(2) In some of its features facial hemihypertrophy appears to have relationship with syringomyelia, and with acromegaly.

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Reviews.

Die Entwicklung des menschlichen Gehirns während der ersten Monate. Von WILHELM HIS. (S. Hirzel, Leipsig, 1904. pp. 176).

THE appearance of this monograph scarcely preceded its lamented author's death, and his precision and genius are so evident throughout it, that we cannot but regret it is the last work of one who has added so much to our knowledge of this branch of cerebral anatomy, who, in fact, almost created it.

His's apparent idleness during the past few years has been deliberate, as it has seemed to him advisable to allow the results of this fruitful period of the study of brain anatomy to accumulate, before concluding his work on its development.

As this volume only contains what has seemed to him definitely certain, it is incomplete in many respects, and is besides, in great part, a reiteration of his earlier publications, when he has been able to confirm or amplify the facts they contained.

His available material had increased to fifty-four embryoes, ranging in age from two weeks to the end of the fifth month, and to their study the same method of reconstruction from microscopical sections was employed. He commences with description of the histological development of the neural tube. The spindle-shaped spongioblasts, the elements of the myelospongium which have developed from the primary epithelium, are arranged radially, and by the syncytial confluence of the protoplasm of their two ends two concentric layers, the laminæ limitantes interna and externa are formed, while the nuclei of the cells lie chiefly in the intermediate zone. These three concentric zones are very apparent after the fourth week, and represent the first differentiation of the neural tube. Later, another layer comes into existence in the outer surface of the tube, the Randschleier, a protoplasmic net free from nuclei. The neuroglia develops only from the myelospongium through the intermediate stage of Deiter's cells; no mesoderm cells migrate into the

neural tube as His formerly maintained. The neuroblasts which begin to appear on the border of the membrana limitans interna arise by the unilateral outgrowth of the protoplasm of germ cells, whose nuclei divide by mitosis. Distinction between these and the spongioblasts is at first very difficult, and can only be definitely determined by their connections with nerve-fibres. All nerve cells, no matter how complex their later arrangement, have their origin in the central portion of the neural tube, and the organisation of the system is dependent on the migration of its cells, and on the arrangement of the fibres which spring from them. The former may remain at the site of their origin, as in the spinal cord; they may migrate to the surface, as those of the cortex of the cerebral hemispheres; or may otherwise change their position in the matrix, as do the cells of the inferior olives and of the pontine ganglia.

All his recent observations support the author's original contention of the origin of each nerve-fibre as the process of a single cell. He argues against Bethe that the origin of fibrils from the cells of the sheath of Schwann has not been definitely proved, free from objection, as there is much room for the misinterpretation of the histological appearances. Further, in mammals the sheaths of Schwann and their nuclei appear relatively later than in the lower vertebrates, on the study of whom Bethe's statements are based, and in man the bundles of nerve fibres are distinct before their appearance. Further, Bethe's observations cannot be applied to the central nervous system.

The development of the ventral portion of the neural tube precedes that of the dorsal. During the first month of embryonic life nerve fibres begin to develop, the first being those of the ventral spinal roots, but soon later the sensory fibres, and, almost simultaneously, those of the acusticus appear. The olfactory fibres can only be seen some time later, and the optic are the last to develop.

The first intramedullary bundles which can be made out are those of the ventral columns. These are chiefly composed of arcuate fibres springing from cells in the dorsal portion of the cord, which enter them directly, or after having decussated in the ventral commissure, but, in addition, cells lying in the ventral portion of the cord give origin to fibres which run longitudinally. At this time the dorsal columns only contain the fibres of the neighbouring roots, and their further development is chiefly due to the longitudinal growth of these.

The metencephalon undergoes analogous changes, but at a

somewhat later period. A ventral commissure of arcuate fibres, similar to that of the cord, which extends from the cervical region to the isthmus, is developed early. So also are the fibres of the dorsal longitudinal bundles, each of which is probably a complex of shorter tracts, which extends caudalwards into the ventral columns of the cord. In the first month, while there are scarcely any neuroblasts in the dorsal portions of the mid-brain or hemispheres, a continuous chain of them extends along the border of the hypothalamus from the optic vesicles to the mid-brain.

The development of the fore-brain is more complicated. The hemispheres appear early, even before the closure of the neuroporus, as rounded evaginations. The rhinencephalon develops basal to the neuroporus, and so cannot at any stage be confused with the pallium, and the corpus striatum from a depressed triangular area ventral and rostral to the hemispheres, and dorsal to the hypothalamus. In the beginning of the second month the primary longitudinal fissure rapidly deepens, and separates off the lateral ventricles from the primarily single cavity. The hemispheres also increase in size and begin to project over the 'tween-brain, and the rhinencephalon is definitely separated from the thalamus.

His joins in the discussion as to the nature of the so-called transitory furrows of the hemispheres, and comes to the conclusion that they are only the result of *post-mortem* shrinkage. The only definite indication of the existence of a true furrow is the thickening of the soft membranes opposite it, or their projection into it.

The hemispheres develop rapidly from the second month till, in the fourth, they have attained almost their normal form. The development proceeds from the region of fusion of the pallium and corpus striatum toward the apex, and, last, to the mesial surface. It is there that the first germ cells, which, by mitotic division, produce the future cortical cells, are found in the inner layer of the hemisphere. The pyramidal cells slowly migrate from the ventricular surface through the thickness of the hemisphere wall into the cortical layer, the first reaching it in about the eighth week. They are generally bipolar structures, with the longer and more definite process directed centralwards. They further differentiate and change their form as they pass out, and accumulate till the cortical zone contains several layers of them. They first appear in the mesial surface of the hemisphere in the third month, but that portion of it and the caudal end of the rhinencephalon where the two hemispheres later fuse and from which the corpus callosum and fornix develop, remain free from cortex.

In the second month the first fore-brain bundles appear; these, which are the thalamic radiations to the pallium, come from the region of the internal capsule, and break up in the lateral surface of the hemisphere. The steady increase in thickness of the hemisphere walls is chiefly due to growth of its intermediate layer (Zwischenschicht), and it is later at the expense of this that the convolution of its surface is effected.

The corpus striatum develops *pari passu* with the pallium. Its anterior end is early divided into three limbs by the Fissura epirhinica, F. mesorhinica, and F. metarhinica. The anterior limb fuses with the lateral wall of the anterior olfactory lobe, and the posterior with the mesial wall of the hemisphere, their union being the structure through which the fornix passes on its way to the corpora mamillaria. The ventro-caudal end of the nucleus caudatus develops considerably later. Then, as the hemisphere bends over the 'tween-brain, the nucleus caudatus curves into semi-lunar shape, with its anterior end resting on the rhinencephalon and its caudal in the inferior horns of the lateral ventricle. The appearance of the internal capsule in the third month divides off the nucleus lenticularis. Embryologically considered, this, with the claustrum, is a portion of abortive cortex rudiment.

From the end of the second month the pallium exceeds the rhinencephalon in size. This is divided into a rostral and a caudal portion by the F. mesorhinica; from the former the olfactory bulb and trigenum develop, and the latter forms the trapezoid area (Trapezfeld) from which the central connections of the olfactory system are developed, and which is of considerable importance in the secondary fusion of the hemispheres. The anterior commissure results from fibres which grow through the secondary fusion of the two trapezoid areas; it first appears in the eleventh week, and its development is complete in the middle of the third month. Similarly, the corpus callosum and fornix develop from the fusion of the limbus areas of the mesial walls of the hemispheres. At first only the middle portion of the former appears, the genu and splenium being of later formation.

The development of the cerebellum begins later than that of the hemispheres. At the end of the second month a prominence appears on each side of the metencephalon, and these two, having increased in size, fuse medially. The earliest portion of the corpora restiformia only contains olivo-cerebellar fibres, whose termination in the vermis is very easily followed.

A concise table shows the dates of the successive appearances of the intramedullary tracts, the spinal root of the trigeminus,

the fasciculus solitarius, and the dorsal longitudinal bundle being among the first to appear, and the cortico-spinal and pontine bundles the last.

The monograph is so replete with facts, newly discovered or authoritatively confirmed, that an adequate summary of its contents would require more space than is here available.

Only one feature offers itself to adverse criticism. The volume is liberally supplied with illustrations, but the majority of these are photographs, often of sections under high magnification, which leave much to be desired in distinctness. They have evidently been deliberately preferred to drawings or diagrams, that the author may represent exactly what he sees; but he has been able to examine them under conditions very different to those of his readers, and they, on the other hand, are ever ready to assume so much scientific honesty on his part as to allow him to temper exactness with clearness. The lack of any lettering on the illustrations often gives considerable trouble in exactly determining what is described, and frequently necessitates repeated reading.

GORDON HOLMES.

Jahresbericht über die Leistungen und Fortschritte auf dem Gebiete des Neurologie und Psychiatrie. VI. Jahrgang. Bericht über das Jahr, 1902. (Published by S. Karger. Berlin, 1903. Price 35 marks.)

THE sixth volume of this Jahresbericht contains a catalogue of all the papers published during the year 1902 on Neurological and Psychological subjects. Not only is it a catalogue, but it also contains a digest of the most important papers on the various subjects. To all those who are engaged in looking up the recent literature of a subject this work is invaluable, for, in many instances, when from the title of the paper it might be considered necessary to look up the original article, the reference to the digest of the paper will show whether it has bearing on the subject under consideration or not. How completely each subject is reviewed may be judged from one instance taken at random, viz.,

the digest on "brain tumours," by Dr. Bruns, for, out of some 135 references on this subject, no less than sixty-two papers are abstracted. The uniformity of arrangement of the subjects is of the greatest value, for it is a simple matter to find out all the papers published within the last six years on a given subject by referring to the heading in the present and past volumes.

FREDERICK E. BATTEN.

Jahresbericht über die Leistungen und Fortschritte auf dem Gebiete des Neurologie und Psychiatrie. VII. Jahrgang. Bericht über das Jahr, 1903. (Parts I. and II. Published by S. Karger, Berlin, 1904. Price 35 marks.)

THE digest of the various papers published during the year 1903 on Neurological and Psychological subjects has been divided into two parts. No alteration has been made in the arrangement of the subjects dealt with, and the two parts complete the digest of all papers on Neurological and Psychological subjects published in the year 1903. The Editor and the publisher are indeed to be congratulated in that they have succeeded in producing this digest within such a comparatively short period after the publication of the papers reviewed therein.

Like its predecessors this volume is a monument of systematic and careful work, and for the purpose of acquiring a complete knowledge of all the recent work on a given subject, there is no review or digest to compare with the above.

FREDERICK E. BATTEN.

Technique de Psychologie Expérimentale. By Dr. TOULOUSE, N. VASCHIDE et H. PIÉRON. Bibliothèque internat. de Psychologie expérimentale, 1904. (Paris: Octave Doin. Pp. 335. Prix 4 fr.).

IN this book Dr. Toulouse and his collaborators at the Ecole des Hautes Etudes claim to have elaborated a system of tests adapted for the psychometric study of individuals. Those who

have read Dr. Toulouse's earlier volume, embodying his interesting experimental researches on the novelist Zola, will be familiar with the general scheme of his present undertaking. The authors advisedly lay stress on the essentially tentative character of the technique proposed; and it would be idle to ignore the defects and errors which are inevitable in pioneer work of this kind. One can but hope that it may pave the way to the ultimate establishment of an internationally recognised system of psychometric tests, analogous to the anthropometric standards of the Frankfort agreement.

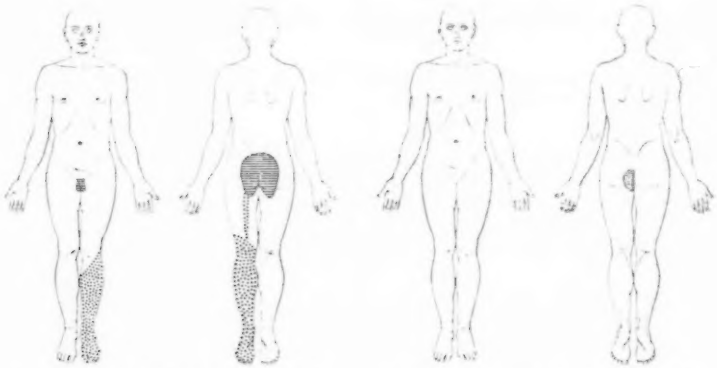
C. S. Myers.

PROCEEDINGS OF THE NEUROLOGICAL SOCIETY OF THE UNITED KINGDOM.

AT the Clinical meeting, held at 11, Chandos Street, on Thursday, October 27, at 8.30 p.m. (patients in the room at 8 p.m.), the following cases were shown :—

Dr. FERRIER and Mr. BALLANCE.—*Case of recovery after operation for cauda equina lesion.*

Mr. C. H., solicitor, aged 41. Patient came under observation in February, 1903, with the following history :—Two attacks of pleurisy with effusion, nine and four years ago respectively. Two attacks of hæmoptysis within last two years. Four



C. H.—Anæsthesia, February 6, 1903. C. H.—Anæsthesia, October 14, 1904.

years ago, when wrestling, he fell on lower part of back and since then has complained of intermittent pains in outer side of left thigh. Six weeks ago pain became worse. Four weeks ago pain appeared in right thigh also, the left lower limb became paralysed

below the knee, and a week later the right also. With the appearance of motor weakness, there developed anæsthesia of perineum and left lower limb and anæsthetic incontinence of urine and fæces. On examination there was no tenderness or irregularity of the spine and only a doubtful bulging over upper sacral region. There was moderate anæsthesia to all forms of stimuli on the left side from L 4. root downwards, and on both sides, more intense, from S 3. root downwards. Movements of left hip and knee were weak. Below the knees there was flaccid paralysis of all muscles on both sides, except feeble flexion of right hallux. Knee jerks, right faint, left absent, ankle jerks absent. Cremasteric reflexes brisk. Bulbo-cavernosus reflex absent, superficial and deep anal reflexes absent. Anæsthetic incontinence of urine and fæces. No bed-sores, but two days before operation there appeared a small area of reddened skin to the left side of the middle line over the sacrum. Occasional partial priapism.

Operation by Mr. Ballance on February 20, 1903. On removing the laminæ of the three lowest lumbar vertebræ, thick tuberculous pus was found, outside the theca, chiefly in front of it. A small cavity was found in the body of the fourth lumbar vertebra.

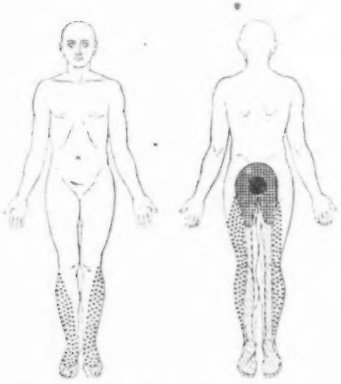
Present condition. October, 1904.—Patient has recovered all movements of both lower limbs, and can walk four miles without fatigue. Gait normal. There is still an area of anæthesia to the left of the middle line, corresponding to the fourth and fifth sacral and the coccygeal root. The anæsthesia does not include the genitals, but affects the left wall of the anal canal. Knee-jerks brisk and equal. Ankle-jerks, left present; right, absent. Plantars flexor. Anal reflexes, superficial and deep, absent, also bulbo-cavernosus reflex. Bladder normal. Imperfect control over rectum if motions are loose. Bowels tend to be confined.

Dr. Ferrier and Sir V. Horsley.—*Case of recovery after operation for tumour of cauda equina.*

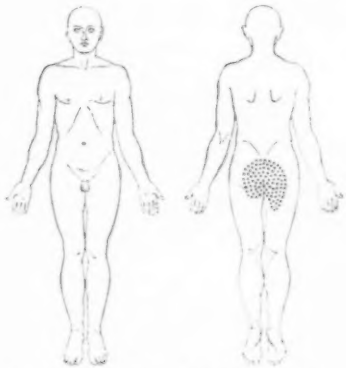
S. C., a boy now aged 14, was operated on by Sir V. Horsley, at the National Hospital, on October 27, 1903. The history prior to operation was as follows:—For twelve months he has had constant dull pain in the right thigh, worse on exertion, and causing him to walk badly. A month ago the gait became much feebler, with difficulty in raising feet from ground, the left foot

being first affected, but latterly the right being the feebler. For six months there has been some delay in micturition, with occasional incontinence. For a month there has been a numb sensation in the soles of both feet, and some loss of sensation observed by the patient in the buttocks.

On examination there was impairment to all forms of sensation in both lower limbs from the fifth lumbar root downwards, symmetrical on the two sides. The anæsthesia increased in intensity from the upper roots downwards, being absolute in the lower sacral root areas. There were wasting and weakness, with diminished faradic reactions, in all the muscles of the left lower limb, and similar weakness, with diminished reaction in the right anterior tibial group. The ankle jerks were absent,



S. C.—Anæsthesia, October 20, 1903.



S. C.—Anæsthesia, October 17, 1904.

so also was the left knee jerk. The right knee jerk was only obtainable on reinforcement. The plantar reflexes were absent. There was delay in micturition, with occasional incontinence. The anal sphincter was normal. There was no spinal deformity.

Sir V. Horsley removed the upper two lumbar and lowest two dorsal spines and laminæ. The theca was seen to be distended in the lower part of the wound, and markedly constricted towards the upper part. On incising the dura, a grayish tumour, $5\frac{1}{2} \times 3$ cm. (microscopically a fibro-myxoma) was exposed, enveloping the cord posteriorly and laterally, not infiltrating it, and apparently arising from the fourth lumbar posterior root on the

right side. The tumour was entirely removed, and the cord was seen to be considerably compressed at this level.

Patient rapidly recovered motor power, and left hospital in January, 1904. Subsequently a dorso-lumbar kyphosis developed, for which he has had to wear a spinal support.

Present condition.—He can walk well, without any abnormality of gait. Occasional slight delay in micturition. No incontinence. Area of anæsthesia limited to lower sacral and coccygeal root-areas, nowhere absolute. Knee jerks, brisk and equal. Ankle jerks, left greater than right. Plantars flexor, cremasters brisk. Bulbo-cavernosus reflex normal.

Dr. COLMAN.—*Case of myasthenia gravis with prominent bulbar symptoms.*

L. M., aged 23. Has had rheumatism twice, and has a slight systolic murmur, but no cardiac symptoms. Subject to sore throats, but has never had diphtheria. Nine months ago noticed that her lips and tongue became fatigued by talking, and that her voice became husky. She also found that her arms and legs easily became tired, the fatigue passing off after a short rest.

On admission to hospital she was well nourished. There was obvious constant weakness, even when at rest, of the levator palpebræ superioris and the orbicularis oris, the lower lip hanging down somewhat. Voice muffled and somewhat nasal. No obvious weakness, when at rest, in limbs. All muscles show rapid "fatiguability." After reading aloud for a quarter of an hour the lower lip becomes pendulous, and the palate almost immobile. Similarly at the end of a meal she has difficulty in preventing food escaping from the lips, and she has nasal regurgitation. These symptoms rapidly pass off if she takes a short rest. Movement of the arms and legs as in knitting and walking quickly causes fatigue, and she has to take frequent rests. *Sensory symptoms.*—When the muscles are fatigued by exertion, she complains of an aching sensation in the muscles concerned, and of tingling in the lips, palate or limbs. Beyond some doubtful anæsthesia of the palate, no loss of sensation to any forms has been actually demonstrated. *Electrical reactions.*—The muscles react readily to both faradism and galvanism, but are rapidly exhausted by repeated weak faradic stimuli ceasing to react to isolated shocks in two minutes, but quickly recovering after rest. It was found that tetanisation did not produce fatigue as quickly as a succession of isolated shocks.

Dr. ALBERT WILSON.—*Progressive muscular atrophy with arthritic changes.*

H. H., aged 25, in perfect health and an athlete until July, 1898, when he injured his right ankle entering a railway carriage. He was lame for two years, and the foot became everted, when it was found that the inner malleolus was broken off (skiagrams). A boot was constructed to rectify this, but a slip off the kerb bruised the ankle, and it began to swell and caused pain and became useless.

The swelling of and pain in the bone continued, and his general health was affected. Cough came on and there were signs of incipient phthisis at the left apex, with moist crepitations.

In May, 1902, I amputated the right foot (Syme). The section of the enlarged tibia was very vascular and the bone soft.

Patient went to Margate for a month, apparently relieved. Here he contracted 'Rheumatism' and was confined to bed with swelling of the left wrist and right elbow and pain in the left knee.

About October or November gradual muscular wasting commenced.

It began in the right biceps and triceps, then in the left forearm, following the swollen joints.

Then the wasting became general and rapid and all his joints seemed to stiffen. Even the jaws became stiff.

Present condition.—The body is devoid of all subcutaneous fat.

Facial muscle of expression active, and the patient can whistle.

The jaws will only separate one inch, and any attempt to force the lower jaw open causes pain in the joints.

The joints of the atlas and axis are anchylosed and much enlarged laterally.

The head is fixed and immovable. The neck muscles are rigid.

The right longissimus dorsi and right trunk muscles are atrophied, so also the supra and infraspinati on both sides.

The right serratus is atrophied, the left is about normal.

Both pectorals, deltoids, triceps, and biceps, are extremely atrophied.

The right elbow joint is swollen and movement limited to half flexion.

Both hands are semiprone and pronate easily, but cannot supinate.

The forearm and hand muscles are much wasted.

Interossei and lumbricales about normal.

The left wrist is swollen and dislocated.

The left carpus is pulled over on the flexor side.

The metacarpals are pulled on to the extensor side.

The opponens is weak. He can move the fingers.

The glutei are extremely atrophied, leaving concavities.

The vasti interni are atrophied, so also the calf muscles.

The left knee is swollen with special enlargement of the internal condyle and extension limited to half the normal.

The left foot and ankle are swollen and œdematous, so that there is no lateral movement.

There is slight anæsthesia in the legs and arms. No analgesia. All the reflexes are much exaggerated, a tap on the knee causing sudden and painful spasm of the whole limb and trunk.

Mr. CHARLES BALLANCE.—*A case of facial palsy treated by hypoglosso-facial and gustatorio-hypoglossal anastomosis.*

J. F., aged 7 years, was admitted to St. Thomas's Hospital last June. Since early infancy he had had purulent discharge from the left ear, and complete left facial palsy. On several occasions glandular tubercular abscesses had been opened in the neck.

June 18.—Removal of temporal bone disease.

June 29.—Hypoglosso-facial and gustatorio-hypoglossal anastomoses carried out. During this operation several caseous glands had to be removed. The facial nerve was found imbedded in scar tissue in the lower part of the parotid gland, and completely severed by old suppuration. On the day after operation, distinct voluntary movement of the left angle of the mouth occurred. This disappeared in a fortnight, and complete atrophy of the left half of the tongue took place.

Present condition.—Commencing movement of the angle of the mouth is present, and the left half of the tongue is much less atrophied than formerly.

Mr. CHARLES BALLANCE.—*A case of facio-accessory anastomosis for facial palsy, with recovery of dissociated movement.*

M. K., a girl, aged 18 years, was admitted to St. Thomas's Hospital in 1902, for facial palsy due to an operation performed

for ear disease at another hospital some seven months previously.

Operation. — August 1902. — Facio-accessory anastomosis. Five months later no recovery had taken place. Patient then disappeared, but was seen eighteen months after the operation. Recovery had then taken place, so that without movement of the shoulder, the previously paralysed face moved voluntarily and emotionally in symmetry with the other side.

Mr. Hamilton Ballance.—*A case of facio-accessory anastomosis for facial palsy.*

A married woman, aged 33, was operated on for chronic right otitis media at the Norwich Hospital in 1901. This was followed by facial palsy. No signs of improvement in six and a half months taking place, facio-accessory anastomosis was performed.

The result has been that the muscles all respond to faradism, and at rest the face is symmetrical, but no movement of the face occurs without movement of the sterno-mastoid and trapezius. During emotional movement of the face the deformity is as great as before the operation.

Dr. Purves Stewart and Mr. Lenthal Cheatle.—*Case of facio-hypoglossal anastomosis.*

J. J., a young woman, aged 26, who had been deaf since childhood from chronic middle ear disease, was operated on six and a half months ago for right-sided mastoid disease. During the operation the facial nerve was divided. Total facial palsy resulted, with loss of taste in the anterior two-thirds of the tongue. A fortnight later, *i.e.*, six months ago, the patient was seen by Mr. Cheatle, who performed end-to-end facio-hypoglossal anastomosis. Two months ago slight voluntary power reappeared in the lower face, so that on pushing the tongue into the left cheek the right angle of the mouth was drawn outwards.

Present condition.—There is hemiatrophy of the tongue, owing to the hypoglossal palsy. The mouth at rest no longer droops on the affected side, and the patient has fair power of movement in the lower facial muscles.

Particular attention is directed to the fact that facial movement occurs not merely in association with tongue movements, but that there is *dissociated* emotional movement, *e.g.*, on smiling.

The upper facial movements have not yet recovered.

Mr. Charles Ballance.—*A case of temporo-sphenoidal abscess with loss of the sense of smell.*

T. M., aged 41, was admitted to St. Thomas's Hospital on October 6, 1903.

History.—Discharge from right ear since early childhood. Twelve months ago son died of cerebral abscess.

Present illness.—Severe headache for one week, chiefly frontal. Yesterday he vomited once. He volunteered the information that for a week he had lost all sense of smell.

Signs and symptoms.—Foul pus in right auditory meatus. Both pupils moderately dilated. Right pupil stabile as compared with left. Slight right optic neuritis. No paralysis of face or limbs. No anæsthesia. Reflexes normal.

Operation.—October 6, 1903. After the completion of the mastoid operation a little pus was visible oozing from the tegmen antri. The tegmen was removed and the stalk of the abscess adherent to it was used for the passage of a drainage tube. Two ounces of fetid pus with gas escaped.

Recovery was rapid and uninterrupted. No hernia occurred. The sense of smell has returned.

Dr. Beevor.—*Pseudo-bulbar paralysis from bilateral hemiplegia.*

S. M., aged 23, soldier, had specific disease in 1900, otherwise healthy, family history unimportant.

In July, 1903, suddenly without loss of consciousness, lost power in *left* face, arm and leg; unable to open mouth for two weeks; speech indistinct. In November, 1903, during sleep, lost power suddenly in the *right* arm and leg, (?) face. Speech was slightly affected. He improved so as to walk and talk fairly well. In June, 1904, had third attack, and was admitted into the Great Northern Hospital, not unconscious, lost power in *left* arm and leg, and face, and control over sphincters lost; speech completely lost, unable to phonate, but could groan; could not swallow; had paralysis of soft palate; could not open or shut mouth, bite, or move the tongue; he could not elevate or retract angles of mouth, purse up mouth, or close eyelids, he could allow them to fall over the eyeballs, but was unable to corrugate the brows. The movements of the eyes normal in all directions, and in looking upwards forehead wrinkled by frontalis. He could not voluntarily inspire or expire, and could not voluntarily cough, though he could do so reflexly. He was very emotional, and

always laughing or crying, and in retraction of angles of the mouth in laughing, the left side moved later and less than right, but in yawning both sides moved equally. The left arm and leg were slightly weaker than the right, but he could perform all movements. The left latissimus dorsi acted well as a unilateral adductor of the left humerus, but in the voluntary bilateral movement of coughing, or even of expiration, there was no movement of either latissimus dorsi, though the muscles of both sides contracted equally in emotional laughing and in reflex coughing. The knee jerks were increased but L. > R., there was ankle clonus on both sides. Plantar reflex gave extension of left big toe and flexion of right. In about two weeks time he could just close the teeth, but he had still to be fed by a nasal tube. In another ten days he could open the mouth, and protrude tongue just beyond the teeth. In ordinary respiration the right side of the chest moved more and sooner than the left, and the same observed in forced breathing, which he could now to a slight degree perform (the opposite to what occurs in hemiplegia). On admission into the National Hospital, on July 29th, he could just pronounce some of the vowel sounds, he could swallow with difficulty, and saliva dribbled from mouth. He could not voluntarily perform defæcation and he had precipitate micturition. He has gradually improved, and can now close the eyes and show his teeth, and can just purse up mouth, can inspire and expire and faintly cough; in ordinary respiration the movements of the two sides are equal, in voluntary inspiration, R. > L. The lesion is considered to be bilateral, due to specific thrombosis of the branches of the posterior communicating arteries to the genu of the internal capsule of both sides, and the great interest of the case is the paralysis of many voluntary bilateral movements about the face and fauces and of respiration with preservation of the emotional and reflex movements, and also with only slight weakness of the voluntary movements of the limbs.

Dr. Risien Russell.—*Case of pseudo-bulbar paralylis* (*double hemiplegia*).

E. G., female, aged 24 years, single. Attack of left hemiplegia in 1896, from which she recovered. Similar attack on the right side eighteen months later, but attended with inability to speak, difficulty in swallowing, with choking and regurgitation of liquids through the nose, and dribbling from the mouth. Recovery of

power in the limbs, but only slight improvement in the bulbar symptoms.

Emotional display in excess. Difficulty in sustaining ocular movements. Movements of jaw slow, spastic and weak. Volitional movements of face weak and laboured. Inability to blow out cheeks or whistle. Excess of expressional movements of face in smiling. Associated movements of face as in firmly grasping an object practically lost. Scarcely any movement of palate on phonation. Movement good in swallowing. Considerable but slow movement on reflex stimulation. Almost complete anarthria. Deglutition difficult and slow. No regurgitation through nose, but liquids dribble from mouth. The tongue is not wasted, but cannot be protruded to any extent nor moved from side to side. Muscles of neck and trunk act well, but latissimus dorsi contract relatively less on coughing than on voluntary depression of the arm. Slight uniform weakness of the limbs, more marked on the right side. No rigidity. No ankle clonus. Plantar reflex flexor in type. Sphincters unaffected.

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EDITOR.